EXPLORING THE NATURE OF TEACHER'S CLASSROOM PRACTICES WHEN TEACHING ELECTRIC CIRCUITS IN A GRADE 12 CLASSROOM: A CASE IN THE TSHWANE WEST DISTRICT

BY

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DECLARATION

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I, Vonani Japhta Ramashia declare that the dissertation entitled ***"Exploring the nature of classroom practices when teaching electric circuits in a grade 12 classroom: A case in the Tshwane west district"*** is my own work and that all of the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

SIGNATURE	**December 2018** **DATE**

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ABSTRACT

The purpose of the study is to explore teacher's classroom practices when teaching electric circuits in a grade 12 classroom. This qualitative interpretive study involves three participants who perceive electric circuits to be a difficult topic to teach in the Tshwane west district, Gauteng Province. The study uses the Classroom Practice Diagnostic framework to present and analyse results. Pseudonyms are used to protect the identities of the participants. The study reveals that teachers' classroom practices differ from one participant to the other, despite the same perception that electric circuits is a difficult topic to teach.

Key words: Teacher Knowledge, Classroom Practice, Instructional Strategies, Interactions, Discourse and Accountability

MANWELEDZO

Ndivho khulwane ya ngundo/Tsedzusulo iyi ndi u bveledza na u tandavhudza mugudisi kha ngudo dza kilaŝini musi a tshi gudisa sekhethe dza mudagasi kha gireidi ya 12(ya vhufumbili) kilasini. Nyangaredzo ya thaluso ya ngudo I katela vhashelamulenzhe vhararu vhane vha vhona sekhete dza mudagasi dzi tshi konda kha Tshitiriki tsha Tswane Vhubhaduvha; na kha vunda la Gauteng. Ngudo iyi I shuma u ita tsedzuluso u itela u netshedza na u ita tsedzuluso yo dzhenelelaho ya mvelelo. Madzina o dzumbamiswaho o shumisa u nwala muvhigo u tsereledza vhashelamuledhe vha ngudo iyi. Tsedzuluso yo dzumbulula uri zwine vhagudisi vha ita kilasini zwi fhambana u bva kha munwe mudededzi uya kha munwe; nga nnda ha ndavhelelo ya uri ngudo ya sekethe ya mudagasi I a konda u funza.

Maipfi a dzhealwaho nzhele: Ndivho ya mudededzi, maitele a kilasini, ndaela, u tanganelana(thanganelano), Nyambedzano na vhudifhinduleli

TSHOBOKANYO

Maikaelelo a serutwa se ke go katisa morutabana gore a nne le bokgone jwa go ruta sekete ya motlakase ka mo phaposing ya gagwe ya materiki.

Ka kakaretso tlhaloso ya serutwa se sa sekete ya motlakase se akaretsa batsaya karolo ba ba raro ba ba reng serutwa se se thata, mme ba tswa kwa Tshwane West le kwa Porofenseng ya Gauteng. Serutwa se se dirisiwa go dira dipatlisiso le go neela dipatlisiso tse di tseneletseng tsa dipholo tsa batsaya karolo. Mo dipatlisisong tse go dirisitswe maina a a bofitlha go sireletsa batsaya karolo ba patlisiso e.

Serutwa se kgotsa patliso e,e re lemosa gore se barutabana ba se dirang mo phaposing se a farologana go tswa go morutabana mongwe le mongwe, ka ntlha ya gore serutwa sa sekete ya motlase se thata.

Mafoko a a tseneletseng:* *kitso ya morutabana, ditiro tsa ka mo phaposing, ditaelo tsa go ruta, batsaya karolo dipuisano le maikarabelo.

ABBREVIATIONS

CAPS	Curriculum and Assessment Policy Statement
CK	Content Knowledge
DBE	Department of Basic Education
IRF	Initiation, Response and Feedback
IRFRF	Initiation, Response and Feedback, Response and Feedback
PCK	Pedagogical Content Knowledge
SMK	Subject Matter Knowledge

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CHAPTER 1
INTRODUCTION

1.1 RESEARCH BACKGROUND

The South African democratic government inherited a divided and unequal education system (DoE, 2004). In order to reverse this, changes were made in the curriculum.

Most of the teachers currently serving entered teaching when education was still an integral part of the Apartheid project (DBE, 2010). Those teachers were not sufficiently equipped to deal with the new curriculum (Mudau, 2013) and as a result are still employing a transmission-absorption paradigm of teaching. Hake (1998) discusses that those teachers using a transmission-absorption paradigm plan instructions that aim at enabling learners to absorb objectives to knowledge that have been verified by other people, usually experts, and transmitted by teachers to the learners. Those teachers used traditional/lecture methods of teaching. In physics, standard lectures did not help most students develop conceptual understanding of fundamental processes in electricity and in mechanics (McDermott & Shaffer, 1992).

The Department of Basic Education continuously organises and conducts workshops with the aim of improving the quality of education. These workshops focus on teachers, however the researcher's own observation was that the workshops paid more attention to what teachers know about a certain topic. Little to no attempts were made to assist teachers on how to teach a particular topic to learners. It is important to understand what a teacher does in the classroom (Mudau, Mundalamo and Sedumedi, 2013). Correctly point out that what teachers do when they teach particular subject matter knowledge is fundamental to student learning. Mudau et al (2013) further indicates that there is limited research on what science teachers do in the classroom.

Consequently, this study explores the classroom practices of teachers in the context of teaching electric circuits in grade 12 classrooms. The problem statement from which the study is rooted upon is outlined below.

1.2 PROBLEM STATEMENT

Poor performance in Physical Science from learners is a cause for concern. Among the causes of poor performance are topics that teachers perceive as difficult to teach (Kriek and Basson, 2008). In 2005, Njoku's study of identification and analysis of topics which teachers perceive difficult to teach found that some teachers find electric circuits to be one of the difficult topics. It is not a surprise, therefore that learners score very low marks in the topic of electric circuit's today (DBE, 2016). The topic of electric circuits in the 2016 Matric final exam paper was the worst answered question, with some learners not even attempting to answer it at all. According to (Ivowi, 1999), difficult concepts are concepts that are difficult to teach and difficult to learn. Furthermore, Onwiodukit (1996) laments that if a concept is difficult for a teacher then the presentation to the learners will be inadequate and they will find it difficult to understand the subject matter. If physical science teachers adopt appropriate teaching strategies and conduct research or make use of research findings on the area of learning difficulties of the students in physics, they would be appropriately guided to carefully select methods of teaching which enhance the understanding of physics concepts and thus be able to remove the difficulties the learners experience (Ogunneye, 2007). Researchers and policy makers have long assumed that teacher characteristics, knowledge and classroom practices had a direct relationship on learner learning (Gess-Newsome, Carlson, Gardner & Taylor, 2010). It is important to investigate what teachers know about the topic, what instructional strategies are used and the type of interaction and discourse and accountability in the science classroom when teaching electric circuits. Consequently, the researcher will investigate the nature of the classroom practices of teachers during the teaching of electric circuits in grade 12.

1.3. THE AIM AND OBJECTIVES OF THE STUDY

1.3.1 The aim of the study:

The aim of this study is to explore the nature of teacher's classroom practices when teaching electric circuits in a grade 12 classroom.

1.3.2 The objectives of the study:

I. To understand the nature of the teacher's knowledge when teaching electric circuits.

II. To explain how the instructional strategies used shapes classroom interaction and discourse.

III. To understand how accountability shapes teachers' instructional strategies, interactions and discourse

1.4 RESEARCH QUESTION AND SUB-QUESTIONS

1.4.1 Research main question

- What is the nature of teachers' classroom practices when teaching electric circuits in a grade 12 classroom?

1.4.2 Research sub-questions were as follows

I. What is the nature of the teacher's knowledge when teaching electric circuits?

II. How do the instructional strategies used by the teacher shape classroom interactions and discourse?

III. How does accountability shape teachers' instructional strategies, interactions and discourse?

1.5. RATIONAL OF THE STUDY

Many South African science educators need content knowledge of how to teach science (Mji and Makgato, 2006). Therefore, these teachers lack appropriate instructional strategies for teaching and often use lecture methods (Omosewa, 2009). In lecture methods the teacher instructs students on what to do instead of activating them to discover for themselves (Milles, 2015). However the evaluation of science teaching calls for a change in paradigm and should invite maximum social interaction in the classroom. According to Ngunyen (2002), social interaction between the students and between the teacher and students plays a crucial role in learning.

In an attempt to link teacher knowledge and practices with student learning, researchers have conducted various studies, however their studies have lacked an in-depth understanding on the nature of classroom practices. Their investigations either focus on what teachers did or knew about the topic or the students and their learning. Much has been documented about electric circuits, including students' misconceptions about simple concepts regarding electricity, (Selen et al, 2001), conceptions of pupils of primary school on the topic of electric circuits (Abdeljalil et al, 2016), the effects of teaching electric circuits (Charilaos, et al, 2015) and physical science based teaching perceptions of the difficulty of teaching electricity (Gunstone et al, 2008). It is on this basis that the primary rationale for this study lies, in the fact that there has been no study that investigates the nature of classroom practices when teaching the perceived topic to be a difficult topic.

Secondly, the strength of this study draws its weight from the fact that there wis continuous poor performance in science despite teachers' workshops conducted to improve it. Thirdly, as a physical science teacher and external examination marker, the researcher's observation is that the question on electric circuits is poorly answered every year.

1.6. SIGNIFICANCE OF THE STUDY

According to McMillan and Schumacher (2001), the significance of the study tells the reader why the study is important and the reason for the researcher's choice of a particular study or problem. This study is of critical importance to science. It aims to contribute towards developing concrete and effective classroom environments that promote understanding and comprehension and which positively enhance effective teaching and learning. This study can assist in teaching what are often perceived to be difficult topics, electric circuit in particular, but this can also be applied to other topics generally perceived as difficult in physics and chemistry.

1.7. DELIMITATION AND LIMITATIONS OF THE STUDY

1.7.1 Delimitation

Delimitation is used to address how the study is narrowed in scope (Creswell, 2007). Diagnosing classroom practices is meant for all physical sciences classrooms. However, since the study adopts a qualitative case study, the investigation has been narrowed to the sampled schools, teachers and classrooms. Purposive sampling will be used to select the suitable participants in this study. This is done to ensure that the researcher acquires the richest data possible that suits the study. Creswell (2007) adds that purposive sampling is used in qualitative research and that participants and sites are selected that could purposefully inform an understanding of the research problem of the study. It is for this reason that the study is confined to only one province, one district, three teachers and three schools.

1.7.2 Limitations

There is no proposed research project that does not have limitations, and not one is perfectly done (Marshall & Rossman, 2006). According to Creswell (1994), limitations are used to identify potential weaknesses of the study. The fact that generalisations cannot be made in a qualitative case study means that the researcher would need to resort to transferability, dependability and credibility, and confirmability. Since the study would be limited to three schools, teachers and classrooms, the findings of this research may differ from another setup with the same context.

1.8 RESEARCH OUTLINE

This section highlights the plan and organisation of all the chapters included in the study

Chapter 1: introduction

This chapter introduces the study, giving background and rationale of the study, the problem statement, aims of the study, research questions, and significance. Delimitations and limitations are also discussed in this chapter.

Chapter 2: Literature Review

Chapter 2 deals with literature review. It discusses electric circuits in the south African curriculum, the purpose of teaching science, the nature of science and prior knowledge, and misconceptions, teaching challenges in science education, instructional strategies, interactions and discourse and conceptual framework.

Chapter 3: Methodology and Design

Chapter 3 deals with the methodology utilised. It describes the research method employed, research design, the nature of research, research context, sampling criteria, data collection instruments, and data analysis and presentation. It will also describe the process of gaining access.

Chapter 4: Data analysis, discussion and findings

This chapter is based on analysis and presentation of the data collected. Literature review is revisited in analysing the collected data.

Chapter 5: Summary of findings and recommendations

A detailed summary of the study and its findings is given in this chapter.

1.9 CONCLUSION

Chapter one presents an overview and general outline of the study. It provides the research background, problem statement and the rationale of the research. The aims and objectives of the study, research questions and delimitations and limitations of the study are also presented. The next chapter is a literature review of related studies previously conducted, predominantly from within South Africa but also international research on similar issues.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

The literature reviewed in this section includes the definition of an electric circuit, the purpose of teaching science, the nature of science, prior knowledge, misconceptions, teaching challenges in teaching science, instructional strategies, interactions and discourse in the science classroom as well as teacher accountability to the system.

2.2. THE ELECTRIC CIRCUIT IN THE SOUTH AFRICAN CURRICULUM

An electric circuit is defined as a continuous conducting path along which electric charge can flow (James, 2012). Electric charge in motion is part of a branch in science known as electrodynamics. Electric circuits are divided into two types of circuits, namely series and parallel circuits, however, the two can be connected into one setup. According to Cutnell & Johnson (2005), series circuits are connected in a way that the current is the same though each device. They further explain that in parallel circuits the device receives the same voltage in the circuits. Thus, the circuits connected in the combination of series and parallel will have the characteristics of both circuits.

Electric circuits have been in the South African science curriculum, be it curriculum 2005, National Curriculum Statement (NCS), Revised National Curriculum Statement (RNCS) or Curriculum and Assessment Policy Statement (CAPS). The teaching of this topic starts at senior phase in grade 8 and 9 in the Energy and Change strand, while in the FET phase (Grade 10-12) the topic falls under Electricity and Magnetism Knowledge area.

It is expected that learners in grade 8 are taught the basics of series and parallel circuits. In doing so CAPS stresses that learners should know the path of the electric current in both circuits. In grade 9 the curriculum policy emphasises both the voltage and current in the circuits.

An introduction of two resistors in each circuit is introduced in grade 10, whereupon learners needs to calculate total resistance. Ohm’s law, Power and Energy are the components of grade 11 in preparing the learners for grade 12 which brings in the concept of internal resistance, electromotive force and series and parallel networks

2.3. THE PURPOSE OF TEACHING SCIENCE

The purpose of teaching science has always been to enhance scientific literacy (National Science Education Standards (NSES), 1996). It is on this basis that different countries adopt curricula towards achieving that goal. The national research council (NRC) (1996) argues that scientific literacy should be the primary goal of science teaching. Furthermore, this supports what the National Research Teacher Association (NRTA) (1971) declared when they said that the major goal of science education is to develop scientifically literate and concerned individuals with a high competence for national thoughts and action. In his study, Hudson (1999) emphasises major goals of teaching science based on the nature of science, namely (1) learning science; (2) learning to do science; and (3) learning about science. In his explanation the development of conceptual and theoretical knowledge is the focus of learning science.

According to the researchers' observation, this is the purpose of most teachers in the sense that in their teaching they stress conceptual understanding. This is because in examinations the questions demand conceptual understanding. Doing science means "engaging and developing expertise in scientific inquiry and problem solving" rather than merely "following a set of rules that requires particular behaviours at a particular stage" (Hudson, 1992). Learning about science stresses learners' understanding about the complex relationship between science and society. This is emphasised in the objectives of Natural Science grade 9 CAPS and Environmental studies. Robin Millar (2004) points out that school science curricula in most countries have two distinct purposes, first it aims to provide every young person with a sufficient understanding of science to participate confidently and effectively in the modern world: a 'scientific literacy' aim. Secondly, advanced societies require a steady supply of new recruits to jobs requiring more detailed scientific knowledge and expertise. School science provides the foundations for more advanced study leading to such jobs.

Although in different terms, Staver (2006) suggests that science education serves three purposes: firstly, it prepares students to study science at a higher level of education. Secondly, it prepares students to enter the workforce, pursue occupations, and take up careers. The third purpose is to prepare them to become more scientifically literate citizens. It follows then that the development of scientific literate citizens is a key goal in science teaching. For the purpose of this study, scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed (NRF, 1996).

Furthermore, the national commission on excellence in education (1983) recommends that the teaching of science in high school should provide students with an introduction to:

a) The concept, laws, and processes of physical and biological science;

b) The method of scientific inquiry and reasoning;

c) The application of scientific knowledge to everyday life; and

d) The social and environmental implications of scientific and technological development.

The researcher agrees with these recommendations because science topics prepare students for work places, especially in engineering and/or science related careers. Moreover, science teaching should equip learners with problem solving skills so that they are able to solve problems facing their environment and societies. Therefore, science teaching should focus on scientific literacy and teach it more effectively (Project 2061, 1993).

2.4 NATURE OF SCIENCE

As stated above the main purpose of teaching science is to produce a scientific literate citizen. To achieve this goal, teachers should have better knowledge of scientific facts that lead to better understanding of the nature of science. According to Lederman (2004), the nature of science (NOS) refers to the epistemology and sociology of science, science as a way of knowing and understanding the natural world, and the role of values and beliefs of scientific knowledge. Epistemology of science concerns itself with ways of knowing and how we know (Akerson and Donnelly, 2010). In their discussion, ABD-EI-Khalik and Akerson (2009) point out that there are various ways of knowing science, one of which is through the teaching of science. When teachers teach science they use different methods that are aimed at achieving a particular goal. Scholars like Magnusson et al (1999) are of the view that science must be taught through inquiry, conceptual change, discovery and didactic methods. In the South African curriculum, the Department of Basic Education asserts that physical science should be taught through inquiry (DBE 2011). In the inquiry method of teaching learners explore content by asking questions, investigating and answering those questions (centre for inspired teaching, 2008). There is a current trend in science education world-wide that calls for inquiry instruction in the classroom. Mokiwa (2014) conducted a study exploring the teaching of physical science through inquiry; he found that teachers do not have a clear understanding of what is meant to teach through inquiry. This poses a threat because the integration of explicit, reflective instruction about the nature of science and scientific inquiry in traditional science content is addressed as a means through which the development of scientific literacy is fostered (Lederman, 2013). The point I here is that when teachers have well informed views about the nature of science and teach with and about the NOS through inquiry, a scientifically literate citizen will be produced.

2.5. PRIOR KNOWLEDGE

Teaching which does not start from the learner's point of view cannot arouse active involvement, which is indispensable for the complex process of constructing scientific thought (Metioui, MacWillie & Trudel, 2016). This is a viewpoint of constructivist learning theory which argues that learner's ideas should be a point of departure in teaching (Hammer, 1996; Smith, Di Sessa, Roschell, 1993). The constructivists' position is that learners do not come into a science classroom without any pre-existing knowledge or beliefs about the phenomena and concepts to be taught. It follows then that the teacher should assess what learners already know in order to design a strategy that allows learners to construct new knowledge from existing ones. Horn (2013) indicates that science teachers should assess learners before teaching to determine the prior knowledge that may be necessary to help learners understand the topic being taught. Additionally, Eryilmaz (2002) reports that students' learning capabilities depend largely upon their prior knowledge and experiences. The teaching of electric circuits starts in grade eight 8, which suggests that by the time learners reach grade 12 they have already constructed knowledge concerning the topic.

2.6. MISCONCEPTIONS

Since learners enter the classroom with pre-existing constructed knowledge it is also important to note that it is sometimes the case that this pre-existing knowledge ideas generated from it are not in harmony with widely accepted scientific views. These misguided views are called misconceptions. Below literature is reviewed about some studies that have studied misconceptions in science, particularly simple electric circuits.

Hiiseyin and Kocakulah (2007) reveal secondary school students' misconceptions about simple electric circuits. The study found that besides the misconceptions identified in the literature review, two misconceptions emerged that were not encountered in the previous studies, namely; the misconception that none of the bulbs are lit when switch is closed, a language based misconception and that bulbs in parallel give more light than bulbs in series, this is a teaching base misconception.

An Explanatory multi-case study by Gaigher (2014) reports on teachers' awareness and planned remediation of learners' misconceptions. Gaigher found that there were a few misconceptions. For example, all teachers viewed practical work or demonstrations as a strategy to correct learners' mistakes. Furthermore, two of the four teachers cited conceptual understanding as another strategy. One of the teachers expected wrong answers from learners but seldom understood the misconceptions leading to those mistakes while the other participant did not expect typical wrong answers. In their study, the two teachers believed that when learners do calculations they will be able to correct misconceptions. However, their study also did not reveal the experience and educational background of the teachers.

Furthermore, Studies regarding misconceptions suggest that a conceptual change could be a powerful framework to address misconceptions. In their conceptual change framework, Treagust et al (2010) point out two types of the framework, namely assimilation and accommodation. This conceptual change approach is embedded within the constructivist view that asserts that learners should think about the concept and principles that the curriculum presents to them. For example, using Ohm’s law to match the limitations of their ideas by drawing ohmic and none-ohmic conductors’ graphs.This will allow the learners to compare the shape of the graphs and predict which conductors obey ohms law. It follows then that misconceptions can make some scientific concepts difficult to understand (Stein, 2008). Because of the use of everyday language and experiences that support these incorrect assumptions, prior teaching and misconceptions may develop after formal teaching which are resistant to change (Tyler, 2002). This could be because some teachers have the same misconceptions held by the learners (Lawrenz, 1986). Additionally, the constructivist learning theorists are of the view that students come to the classroom with preconceptions which were formed during their interactions within the physical and social environment, and those preconceptions affect learning (Pfundt and Duit, 2006). Words such as power, flow and current are used in everyday language and this may result in the formation of misconceptions which may remain persistent despite efforts to teach scientifically accepted theories and concepts (Driver & Guesne, 1985). Thus, in achieving misconception dissonance, teachers should engage learners in activities that will enable them to be aware of the limitations of their preconceptions rather than merely transmitting information. The researcher learned from the literature reviewed that misconceptions can be developed in many ways and that they can affect teaching and learning. However, there are various remediation strategies that can be used to correct misconceptions. These strategies include conceptual change, conceptual understanding and practical work. Moreover, teachers with a good understanding of learners’ misconceptions can select better strategies to correct misconceptions than those with a poor understanding.

2.7 TEACHING CHALLENGES IN SCIENCE EDUCATION

Among the teaching challenges facing science education, and in particular physical science, is how teachers teach science (Makgato, 2003). These teachers have very little knowledge on how to teach certain topics because many teachers teaching science in most of the schools specialise in science, but not in science education (Omosewo, 2009). Although some of these teachers know the topic they are going to teach at a deeper level (McDermott, 2006), in the researcher's view they lack effective strategies to teach the topic in an accessible way to the learners. It follows then that these teachers use traditional or lecture methods when teaching science. Lecture method has been criticised in science education because it has been reported to lack an effective approach and causes poor academic performance (Aina, Kala and Langenhoven, 2015).

A study conducted by United Nations Educational, Scientific and Culture Organisation (UNESCO) (2010) reports that science education faces the challenge of a shortage of quality teachers with pedagogical, didactic and subject knowledge. In their study that explores the influence of subject matter knowledge on pedagogical content knowledge, Rollnick, Bennett, Rhemtula, Dharsey and Ndlovu (2008) report that some teaching challenges in physics originate from the teachers' subject matter knowledge (SMK), which is not well developed. Although the subject matter knowledge has been quoted by researchers as being among the challenges facing science education, SMK alone cannot be the only factor. Below studies that investigate teaching difficulties in science education will be discussed. Mudau (2013) uses the classroom practice Diagnostic framework to evaluate teaching difficulties. In his study he focuses on the interaction and discourse. Mudau (2013) found that teachers have teaching difficulties when teaching certain science topics, such as vertical projectile motion.

In another study by Nthoesele Mohlouoa, Marissa Kollnick and Samuel Oyoo (2013), which investigated teaching difficulties when teaching radioactivity using content representation to assess teachers pedagogical content knowledge, they found that teaching difficulties could be influenced by the learning difficulties resulting from the language of instruction. The concept of electricity is abstract and hard to grasp. This can cause another challenge in the teaching of science (Gunstone et al, 2009; Schwartz and Landerman, 2008). Because of the nature of the content itself, being difficult and causing teaching challenges, many models of and analogies for electricity have been used, but none of them fully explain all of its aspects (Frederiksen, White, & Gutwill, 1999; Hart, 2008).

McDermott and Shaffer (1992) report that ''many students have persistent conceptual difficulties with analysing simple electrical circuits, such as an inability to apply formal concepts related to current, voltage, and resistance (e.g. a failure to distinguish between the equivalent resistance of a network and the resistance of individual elements; the belief that direction of the current and order of elements matter; and difficulties in identifying series and parallel connections)''. Therefore, this proves that there is not one single challenge facing science education. Challenges can stem from teacher knowledge, instructional strategies, interaction and discourse or it could be because of accountability to the system. Therefore, an in-depth understanding of what and how teachers teach concepts that are perceived to be difficult is fundamental.

2.8 INSTRUCTION STRATEGIES

The aim of teaching science is to help learners develop problem solving skills and inquiry skills (DBE, 2011). Achieving these skills can be done in many ways including teaching science through science teachers. These science teachers know some things not understood and/or known by learners, he/she then assists learners to progress from a state of not understanding to a state of understanding and/or knowing more. To help the learners understand, the teacher uses pedagogical content knowledge (PCK), which according to Shulman (1986), is a special kind of knowledge that teachers have about how to teach particular content to particular students in ways that promote understanding. This knowledge includes a knowledge of instructional strategies. It is the effective strategies that can be used to teach the content in ways that promote understanding.

2.8.1 Epistemological perspectives

According to Mudau (2013), epistemological perspectives refers to how a teacher demonstrates through practice how knowledge is acquired. This is of paramount importance because teaching necessarily begins with a teachers' understanding of what is to be learned and how it is to be taught (Shulman, 1987). There are two kinds of epistemological perspectives, namely empiricism and rationalism.

Empiricism has to do with the gaining of knowledge through experience. This suggests that learners gain knowledge through their senses. Here, the teacher in his/her demonstration uses an example to introduce the lesson, the deductive teaching strategy. On the other hand, rationalism has to do with the gaining of knowledge through reasoning. Teachers who advocate this approach believe that knowledge is found within the learners themselves. For example, the teacher will draw an electric circuit diagram and allow learners to identify which resistors are connected in series or parallel. They then involve the learners throughout the lesson, the inductive teaching strategy. The researcher's view is that the teacher should intertwine these approaches in his/her presentation. For example, for the deductive teaching strategy, the teacher can use the empirical strategy to introduce a lesson and actively engage learners in his/her lesson presentation through the inductive teaching strategy.

2.8.2. Explanatory Frameworks

Explanatory Frameworks entail analogies, modules and/or illustrations that the teacher use to make the learning of certain topics accessible to learners. Certain science topics such as electric circuits are perceived to be difficult to teach because they are abstract and complex in nature (Gunstone et al, 2003). It follows then that teachers need to use analogies as a framework to comprehend the content in order to effectively teach it to the learners. However, each analogy has conceptual advantages and disadvantages. It is important for the teacher to assess the strengths and weaknesses of a particular analogy before presenting the lesson to the learners. Further, the use of analogies sometimes does not get the content across, hence the researcher is of the opinion that the use of examples to illustrate abstract concepts can also assist learners in comprehending the content, especially when the intention is to equip learners with critical thinking skills that learners can use to solve electric circuit problems.

2.8.3 Activities

According to Mudau (2016), activities include problems, demonstrations, simulations, investigations or experiments which the teacher uses to help learners comprehend the content. Facilitating learning can occur through experiments, which is backed by Hofsten (2004), who points out that teaching strategies incorporating experiments are considered to be the most important educational tools in a science classroom, especially for teaching difficult or abstract concepts. Electricity is perceived to be a difficult topic to teach by some science teachers (Gunstone et al, 2008). The use of experiments in teaching electric circuits should enhance and improve learning. The use of examples and computer simulations as well as hands-on activities about electric circuits have been found to be among the most innovative science teaching and learning methods (Ekmekci, 2015). Simulation can make the content more easily understandable (Jaoko & Nurmi, 2008) because it allows to learners to use a computerised version of a model to directly manipulate initial conditions and immediately see the impact (Zacharia, 2005). This model can be used to verify Ohm’s law in the electric circuit topic. Therefore simulations as an activity may develop conceptual understanding.

2.8.3 Didactics

Didactics refers to traditional teaching methods like lecture as well as demonstration methods, which the teacher uses (Mudau, 2016). In the lecture method the teacher tells the students what to do instead of activating them to discover for themselves (Mules, 2015). Telling learners what to do deprives them of an opportunity to develop problem solving skills and inquiry skills. Furthermore, these methods are one-way processes unaccompanied by discussion, questions or immediate practice, which makes it a poor teaching method (Hatin, 2001). This is against what the Department of Basic Education

(DBE) (2001) stated, that for a subject to be regarded as science, inquiry method should be used. Scientific inquiry is an approach wherein learners explore content by asking questions, investigating and then answering those questions (Centre for Inspired Teaching, 2008). However, the researcher is of the view that there is room for lecture method if appropriately used in the science classroom, for lecture methods can be used for factual statements and or introduction of a topic.

Therefore, understanding what teachers do when they teach difficult concepts is fundamental. This is in support of what Guess-Newsom et al (2010) point out, that teachers' characteristics, knowledge and classroom practices have a direct relationship to leaner learning.

2.9. INTERACTIONS AND DISCOURSE

Interactions and discourse in the science classroom between the teacher and students is fundamental to learning because it is central to the meaning making process (Mortimer & Scott, 2003). Chin (2006) correctly points out that student's learning in the science classroom primarily comes from the teacher talk and teacher-student talk. It is for this reason that many frameworks have been developed to analyse science teaching. Mudau (2017) evaluates teaching difficulties when teaching projectile motion, a topic some teachers perceive to be difficult to teach. In this study, he uses the classroom practices diagnostic framework and focuses on the interaction and Discourse and he uses the Initiation, Response Feedback, Response, Feedback (IRFRF) framework by Mortimer & Scott (2013) to analyse the types and patterns of discourse and the communicative approach the teachers used during teaching. Mudau (2017) interviewed and observed three teachers who perceived projectile motion to be a difficult topic to teach. He found that the type and patterns of discourse used by both participants was Initiation, Response, Feedback (IRF) and authoritative. However, teachers' communicative approaches differed in the sense that one teacher's approach was interactive-authoritative while the other used non-interactive-authoritative. Mudau's (2017) study did not indicate the experience and educational background of the teachers, something this study will cater for.

Lousa, Zacharia and Tzialli (2012) investigate ways and characteristics of teacher talk in science classroom. Their aim was to develop a framework that will account for classroom discourse initiated by students. In their framework Identification, Interpretation-Evaluation, Response (II-ER), they analyse teacher discourse using student utterances. This framework can be viewed as student-teacher-student in the sense that students initiate the interaction. One experienced teacher was interviewed and videotaped teaching various science topics in a two year project. The researchers found that during interviews five themes emerged, namely:

i. The teacher was sensitive to the context and epistemological properties of the student discourse.

ii. The teacher focused on student thinking.

iii. The teacher gave students the responsibility of the content of the conversation.

iv. The teacher had a large repertoire of teaching strategies from which to choose, and lastly;

v. The teacher performed a mental process for dealing on how to respond to each student utterance.

Although the aim of the framework they used was to account for teacher responsiveness, which includes student knowledge claims, reasoning, epistemologies, and experiences, it views the teacher discourse as a function of and as a response to student discourse. The II-ER framework is inappropriate for the purpose of this study, therefore the IRFRF by Mortimer & Scott (2013) will be employed for this study because it entails the communicative approach, patterns of discourse and teachers' interventions.

Below is a brief explanation of the framework.

Focus	1 Teaching purposes	2. Content
Approach	3. Communicative approach	
Action	4. Patterns of discourse	5. Teachers interventions

The teachers' purpose refers to what the teacher is trying to achieve, the lesson or topic outcomes such as developing scientific story. Content refers to the focus of teaching. This could be everyday or scientific, descriptive, explanatory or generalised; empirical or theoretical in nature. Patterns of discourse refer to the IRF or IRFRF. Teacher interventions refer to ways in which the teacher assists his/her students in accessing his/her story. This could be in the form of marketing key ideas by use of repetition. The four classes of communicative approach that makes the IRFR framework different from other frameworks including the IRF is discussed below:

	Interactive	**Non-Interactive**
DIALOGIC	**A. Interactive / Dialogic**	**B. Non-interactive / Dialogic**
AUTHORITATIVE	**C. Interactive / Authoritative**	**D. Non-interactive/ Authoritative**

The communicative approach focuses on questions such as whether or not the teacher interacts with students (Scott, 2003). Mortimer and Scott (2003) divided the communicative approach framework into four classes, namely: interactive/authoritative, interactive/dialogic, non-interactive/dialogic and non-interactive/authoritative. According to Chin (2006), in an interactive/authoritative communicative approach the teacher invites responses but discounts them if they are incorrect because the teacher focuses on one point of view. The teacher asks questions and expects students to give a particular answer, which the teacher believes is the only correct answer to the question. Anetller and Scott (2003), indicate that in an interactive/dialogic the teacher and students consider a range of ideas. Both teacher and students explore and work on different points of view. By contrast, in the non-interactive/dialogic the teacher revisits and summarises different points of view. Student response is not invited but the teacher includes students' views in his/her presentation. And lastly, in the non-interactive/authoritative communicative approach the teacher presents a specific point of view, according to Chin (2006), this approach is best represented by formal lecture method.

2.10 DISCOURSE IN THE SCIENCE CLASSROOM.

Language is the primary semiotic resource in constructing knowledge about the world (Angel et al, 2017), language and discourse are co-dependent. This suggests that for a discourse to take place both the teacher and learners should know the required scientific language. This supports what Lee (2005) emphasised, that teachers need to have the knowledge of the linguistic abilities of their students to enhance meaningful learning.

Therefore, to have an in-depth understanding of science classroom discourse the three types of science discourse identified by Chin (2006) and Mortimer and Scott (2003) are discussed below:

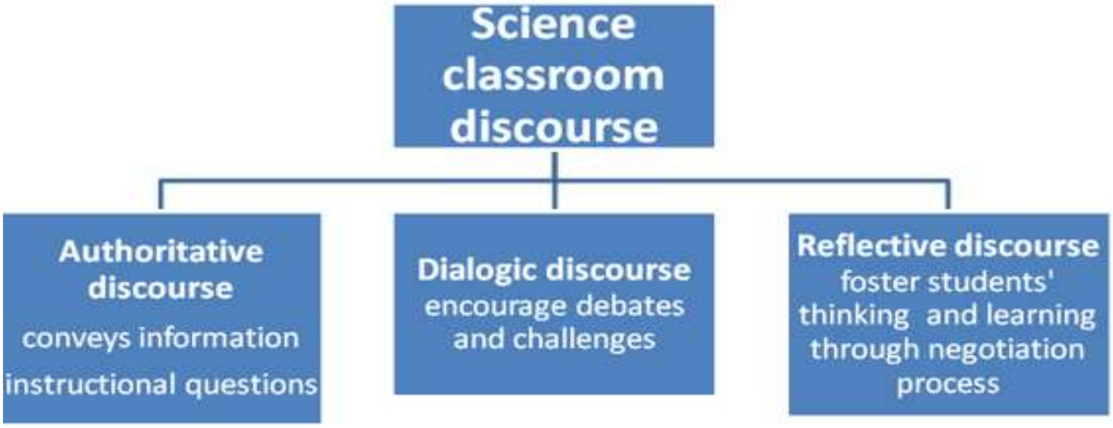


Figure A: Types of science discourse identified by Mortimer and Scott (2003)

In an authoritative discourse only the teacher and textbook knowledge is accepted. Students' views are likely to be reshaped or ignored by the teacher. This type of discourse promotes the transmission of knowledge and recitation. Most importantly knowledge is given. In a dialogic discourse the interactions between the teacher and students contributes to knowledge construction. This is a transformation of understanding the type of discourse and it is centred on the discussion paradigm. Lastly, reflective discourse involves the negotiation of alternative ideas rather than the transmission of ideas. This type of discourse is embedded within constructivists learning theory and supported by socio-cultural learning theorists. Therefore, since one of the research questions attempts to understand how teacher's instructional strategies shape interactions and discourse in the classroom, these three types of discourse provide the desired results.

2.11. TEACHER ACCOUNTABILITY IN THE SCIENCE CLASSROOM

Jita (2004) espouses three themes of accountability that may shape the science teacher's practice. There is the accountability to the system theme. This accountability refers to the amount of content covered by the teacher to prepare his/her students for the examinations as well as "the number of students in his/her previous classes, who have made it through the matriculation examination" (Jita, 2004:16). The focus here is to complete the syllabus in the shortest period of time in which students are usually then drilled on how to answer examination questions. Of course, the ultimate goal is to have high percentages of achievements by students as envisaged by the Department of Basic Education. The teacher's focus on how his/her students make meaning of concepts and their applications to the student's personal life (Jita, 2004) is the accountability to the subject. Furthermore, it highlights the instructional strategies and learning context designs that a teacher uses to facilitate conceptual comprehension (Jita, 2004). From this accountability the explanatory frameworks that the teacher uses to enable his/her students to access the subject matter and make meaning as well as apply it is of paramount importance to the teacher. The last accountability listed by Jita (2004) is accountability to the learners, which focuses on inclusivity. The teacher makes an effort to teach such that all students are catered for. For example, allowing some explanation in the most spoken language in the classroom as well as using students' own experiences to enhance their comprehension of the science subject matter.

2.12. CONCEPTUAL FRAMEWORK

Miles and Huberman, (1994, p. 18) define a conceptual framework as a "visual or written product, one that explains, either graphically or in narrative form, the main things to be studied, such as the key factors, concepts, or variables and the presumed relationships among them". For the researcher to understand and explain the main things to be studied, this study adopts the Classroom Practice Diagnostic Framework (CPDF) (Mudau, 2013) as the conceptual framework. The conceptual framework is not ready made, thus it can be borrowed from elsewhere (Maxwell, 2005). Bearing in mind the nature of the research question(s), it made more sense to borrow the framework from Mudau (2013) because it has been designed for teachers who perceive certain science topics to be difficult to teach. The study intends to study teachers who perceive electric circuits to be a difficult topic to teach. Additionally, this conceptual framework has proven effective to diagnose classroom practices when teaching the perceived to be difficult topic (Projectile Motion) and it has also been used to analyse the classroom interactions, discourse and instructional strategies (Mudau, 2016). The CPFD is a perfect match for the study since the researcher intends to investigate the aspects entailed in the framework.

Maxwell (2005) points out that conceptual framework is primarily a conception or model of what is out there that you plan to study and what is going on with these things and why. He further elaborates that it is a tentative theory of the phenomena that you are investigating. Below is the CPDF with domains to be studied as borrowed from Mudau (2013).

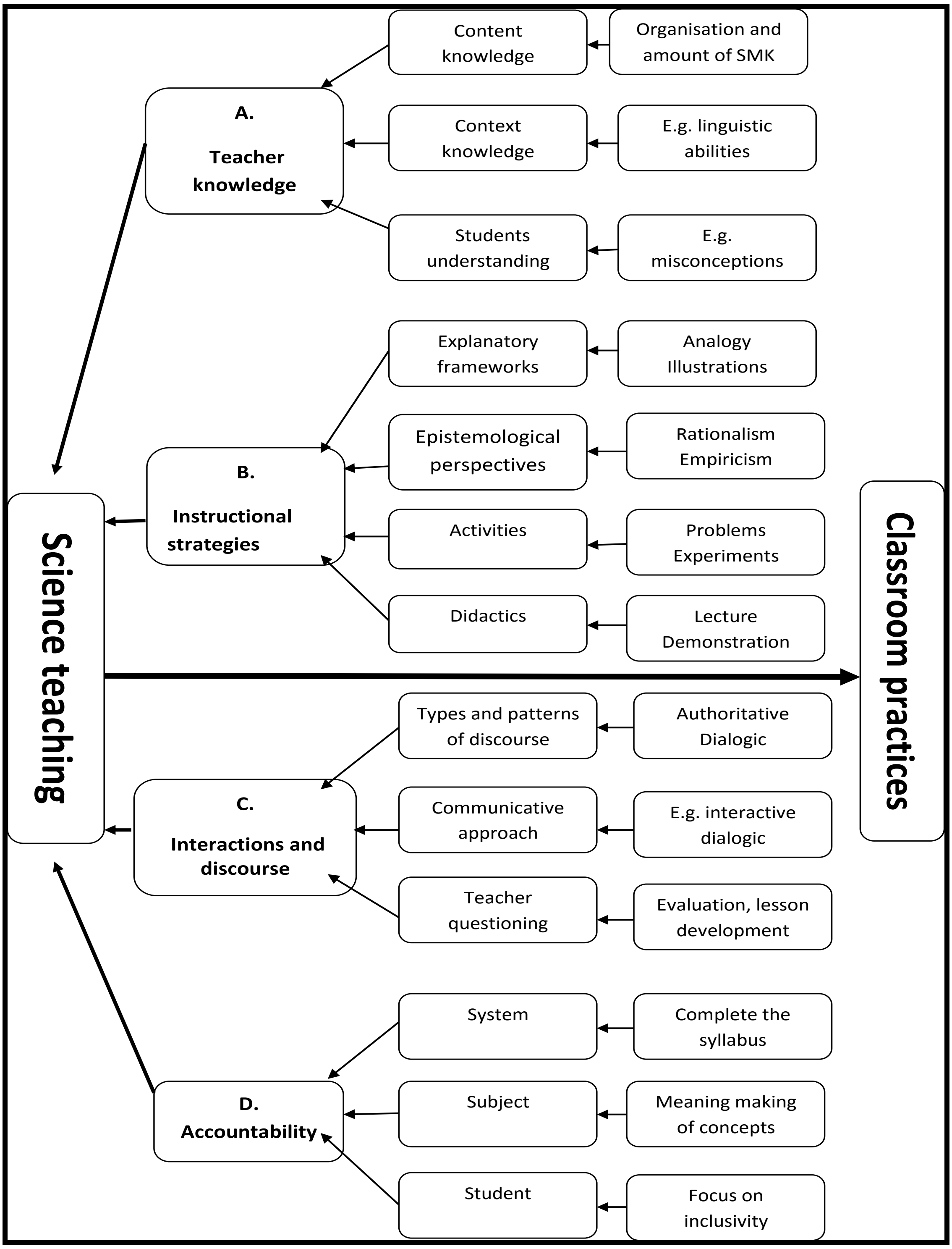


Figure B: The classroom practice diagnostic framework (CPDF)

Frame A (Teacher knowledge)

Teacher knowledge is made up of content, context and students' understanding knowledge (Mudau, 2013); content knowledge in this instance means the teachers' organisation and amount of subject matter knowledge with a specific focus on electric circuits. The context focuses on the classroom size, linguistic abilities, time and many other contextual factors. Lastly student-understanding will focus on pre-existing knowledge and misconceptions. Misconceptions about electric circuits have been investigated and it has been found to be among the factors hindering effective learning.

Frame B (Instructional strategies)

According to Mudau (2013), instructional strategies are informed by teachers' knowledge. Thus, for the teacher to select the strategy that promotes the means to an end, teachers must know the content, context as well as the students' level of understanding. Mudau (2013) further explains that the instructional strategies are made up of epistemological perspectives, which entails rationalism and/or empiricism, explanatory frameworks (analogies and illustrations), activities that includes problems and experiments and didactics, which also entails lecture and demonstrations.

Frame C (Interactions & Discourse)

Frame C is the culmination of interactions from Frame A and B (Mudau, 2013). This frame is strongly supported by constructivist learning theories. This is backed by empirical studies that reveal that the constructivists' approach to science teaching produces more positive effects than the traditional approach. Constructivists' viewpoint is that reality is subjective and can only be contracted through social interaction and through the empathetic understanding of people (Brandon, 2010) . For the purpose of this study, interaction and discourse entails the types and patterns of discourse, thus it will give attention to the three types of science classroom discourse, namely authoritative, dialogic and reflective discourse. Secondly, it entails the types of communicative approaches, namely the interactive and dialogic. Thirdly, it entails the teacher questioning whether it is used for evaluative or lesson plan development.

Frame D: Accountability

Jita (2004) espouses three themes of accountability which may shape the science teacher's practice. There is the accountability to the system theme. This accountability refers to the amount of content covered by the teacher to prepare his/her students for examinations as well as "the number of students in his/her previous classes, who have made it through the matriculation examination" (Jita, 2004:16). The focus here is to complete the syllabus in the shortest period of time in which students are then usually drilled on how to answer examination questions. Of course the ultimate goal is to have high percentages of achievements by students as envisaged by the Department of Basic Education.

The teacher's focus on how his/her students make meaning of concepts and their applications to the student's personal life (Jita, 2004) is the accountability to the subject. It highlights the instructional strategies and learning contexts designs that a teacher uses to facilitate conceptual comprehension (Jita, 2004). From this accountability the explanatory frameworks which the teacher uses to enable his /her students to access the subject matter and make meaning as well as apply it, is of paramount importance to the teacher.

2.13. CONCLUSION

In this chapter the research has indicated the issues surrounding electric circuits in the South African context and internationally. The chapter started by discussing the purpose of teaching science, the nature of science and prior knowledge and misconceptions associated with electric circuits. The literature review mainly focused on the instructional strategies teachers employ in the classroom when teaching science. It also tapped on the type of interactions and discourse in the classroom. Accountability in the science classroom by the teacher was also reviewed. The literature has also revealed why some teachers perceive electric circuits as a difficult topic to teach. In this chapter, the researcher has also indicated the aspects to be studied using the classroom. Research methodology, research design, nature of the research and research context will be presented and analysed in chapter three of the study.

CHAPTER 3:
METHODOLOGY AND RESEARCH DESIGN

3.1 INTRODUCTION

This chapter presents the methodology and design of the study, describing the research approach, the nature of the research, the context of the study, as well as the techniques and procedures used in data gathering. In addition, it presents the steps to analyse and be interpreted. Lastly, it presents the ethical considerations of the study.

3.2. METHODOLOGY AND RESEARCH DESIGN

3.2.1 Methodology

Research is a systematic and methodological process of inquiry and investigation with a view to increase knowledge (Maile, 2014). Strauss and Corbin (1990) correctly indicate that the researcher can choose to use a qualitative or quantitative research approach depending on the nature of the research problem. This study is descriptive and interpretive in nature. Qualitative research focuses on the description and interpretation of data and might lead to the development of new concepts, theories, or to an evaluation of an organisational process (Hancork, Ockleford and Windridge, 2009). It is against this background that the study adopts a qualitative research method because a qualitative approach allows the researcher to describe what the teacher does in the classroom. Furthermore, since the researcher is an experienced teacher in physical science, qualitative offers the researcher an opportunity to interpret collected data as well. Qualitative research as defined by Myers (2009) is naturalistic, it attempts to study the everyday life of different groups of people and communities in their natural setting, and it is particularly useful to study educational settings and processes. It follows then that qualitative research was the appropriate method because it is designed to help researchers understand people and the social and cultural context with which they live (Myers, 2009). The researcher was not aware of any study which investigated the nature of classroom practices when teaching the perceived to be difficult topics. This added more weight to use qualitative method because it can be used to explore and discover issues about problems at hand because very little is known about the problem (Demegan and Fleming, 2007). Furthermore, the researcher interviewed teachers and got into the classroom to understand and explore problems facing teachers when they teach electric circuits. According to Myers (2009), qualitative research is designed to help researchers to understand people and the social and cultural context with which they live, in this particular case, the classroom.

3.2.2 Research Design

Research design serves to plan, structure and execute the research to maximise the validity of the findings (Mouton, 1996). This study used four teachers as participants. Thus, it was a multiple case study method (Stake, 2006). According to Yin (2003), a case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when boundaries between phenomena and context are not clearly defined. Case studies allowed the researcher to systematically record data from questionnaires, interviews and observations. Moreover, this was a descriptive and interpretive case study because the researcher describes the data as it occurs in the classroom and each case is analysed with its own merits, thus, it was not a comparative study.

This study also aims to improve teachers' classroom practices. Stufflebean (2000) points out that the underlying philosophy of a case study is "not to prove, but improve". Additionally, the classroom practice diagnose framework as adopted by the study is inductively used to analyse the data collected. It gives the researcher an opportunity to frame the case study with CPDF because case studies allow the researcher to analyse, interpret and theorise phenomena against the background of the theoretical framework (Lin, 2003). Furthermore, in a case study events and situations are allowed to speak for themselves, rather than to be largely interpreted, evaluated or judged by the researcher. The researcher allowed the participants to speak for themselves and where interpretations were needed it was verbatim. Therefore, methodologically the study is a qualitative multiple case study.

3.3 THE NATURE OF THE RESEARCH

This study is supported by interpretive paradigm. Proponents of the interpretive paradigm are of the view that reality is socially and culturally constructed and not transmitted. Part of the study is to investigate teaching difficulties from interaction and discourse in a science classroom. This allows the researcher to study the type and patterns of discourse. It also allows the researcher to look at the communicative approach the teacher uses in the classroom. It is important because the interpretive paradigm puts an emphasis on language to most closely reflect the participant's perspectives. Language is important in a science classroom because it can be a gatekeeper or a bridge to science discourse (Moore, 2007).

The interpretive paradigm offers the researcher the opportunity to interpret and gain an understanding of teacher's actions. The researcher also uses his personal experience as a science teacher with the literature review and the conceptual framework to describe teacher's actions from the position of the teachers. This is because proponents of the interpretive paradigm are of the view that the researcher is not a tabula rasa. In telling their story, the interpretive paradigm describes and interprets how people live in a particular context (Du Plooy et al, 2015). The researcher describes the context in which the study took place so that other researchers are able to replicate this work. However, this does not mean the findings will be the same because people interpret the truth independently. This is because the environment in which people live influences them over time continuously.

The interpretive paradigm uses a qualitative research approach to search for the truth. Unlike in the positivism paradigm where the theory is formulated first and hypothesis is used to test the theory, the researcher collects data, analyses it and formulates a theory against the data and analysis. Moreover, the findings are not to be generalised because the study was context sensitive, thus it is heavily dependent on the teachers studied in the Tshwane West District.

3.4 RESEARCH CONTEXT

The study was conducted in the Republic of South Africa (RSA). The RSA divides its education department into two, namely the Department of Basic Education (DBE), which is responsible for primary and secondary schools, and the Department of Higher Education and Training (DHET), which is responsible for post-school education and training. The DBE is a national department which is comprised of nine Provincial departments of Education (PDE). The PDE is responsible to achieve the vision and mission of the DBE throughout its districts. The Gauteng province was used in this study.

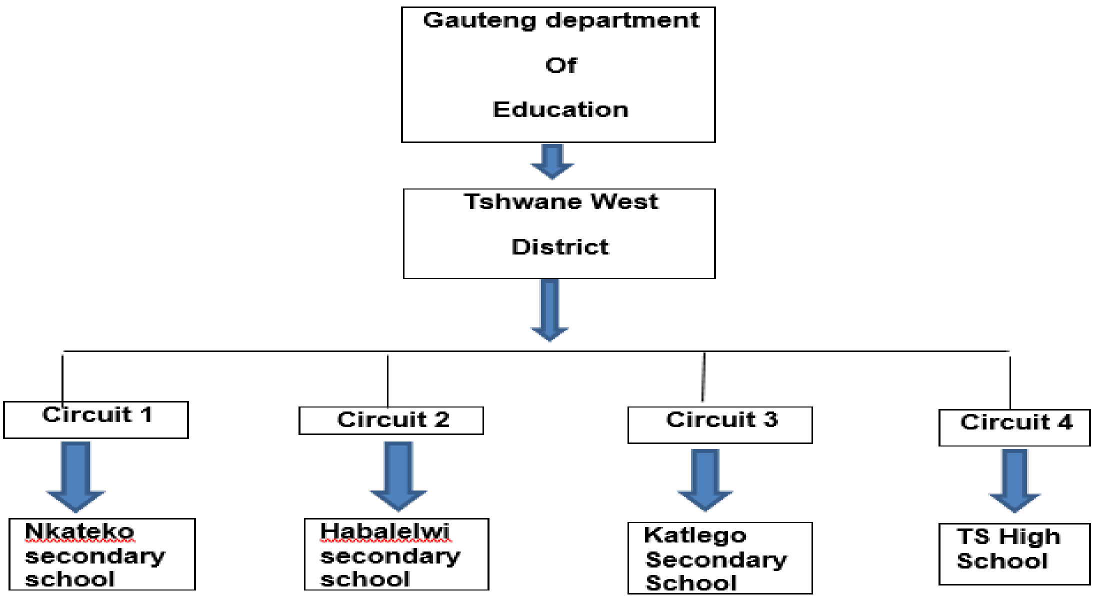


Figure C: Research context

Because of its proximity to the Researcher, Gauteng cost less money and time in terms of travel. The use of one province did not affect the results because sampling in qualitative research is relatively limited, based on saturation, not representative, with the size not statistically determined and it involves low cost and less time (Gay, 1992). The Gauteng department of education (GDE) is responsible for 16 districts. The Tshwane west District (DI5) was chosen because of its proximity to the researcher. The researcher serves as a physical science teacher and the Departmental Head in one of the schools in the district. D15 has 181 schools with most of them situated at the periphery of towns and cities with a low socio-economic status for most of the residents (Ramnarain and Schuster, 2014). Furthermore, most teachers and learners use the language of teaching and learning, English as a second language.

3.5 POPULATION

Teachers teaching grade 12 in the Republic of South Africa are the population of the study. This is because this is the total group of people from whom information was required (Wiid and Diggine, 2013). However, not all teachers teaching grade 12 would provide the researcher with relevant data, for example teachers teaching history. It follows then that for the study to gain sufficient and relevant information, physical science teachers were considered as a target population. Target population involves everyone who falls within the population parameters. South Africa has too many teachers teaching grade 12(DBE, 2011) and this means that the target population is very large and widespread. It is likely impossible for the study to consider all teachers teaching grade 12 science because of limiting factors such as time and money. For these reasons the study focuses only on one province, one district and three teachers. This made sense because the researcher could easily access the province, district and teachers, a population type called accessible population.

3.5.1 Sampling procedure

Criteria

Tshwane west district has a culture of content discussion workshops. During these workshops teachers from five clusters, namely Soshanguve, Ga-Rankuwa, Mabopane, Winterveld and Pretoria north meet and discuss strategies they can use to teach a particular topic. These workshops normally happen before the start of each topic. For example, if the annual teaching plan indicates a date from which electric circuits must be taught, the day before the prescribed date teachers meet and discuss the content and strategies of electric circuits. While teachers were discussing electric circuits, some teachers indicated that the topic is difficult to teach. Additionally, the chief marker indicated that learners perform poorly in electric circuits every year. Among the reasons indicated is that the learners have many misconceptions, the nature of the content itself and learners fail to understand the language used.

It is for these reasons that the researcher used convenience sampling in the first stage of the study to identify teachers who perceive electric circuits as a difficult topic to teach in the Tshwane west district during workshops. This type of sampling is used to choose the nearest individuals to serve as respondents and continuing that process until the required sample size has been obtained or those who happen to be available and accessible at the time (Cohen, Manion and Morrisson, 2011). To achieve this, the researcher distributed a questionnaire (Appendix A). This questionnaire consisted of a list of grade 12 (Physics) topics in the Curriculum and Assessment Policy Statement (CAPS).

Chemistry topics were excluded to ensure that the questionnaire was short and teachers did not lose interest. Babbie (2007) defines a questionnaire as a document containing questions and/or other types of items designed to solicit information appropriate for analysis. The participants were requested to rate the difficulty of the topics using a tick. The researcher also collected all of the questionnaires since they were administered in his presence.

In the second stage, purposive sampling was used to select four teachers from the collected questionnaires. Silverman (2000) describes purposive sampling as a strategy in which a particular case is chosen because it illustrates some feature or process that is of interest for a particular study. Identifying teaching difficulties when teaching electric circuits in a grade 12 classroom was the main interest of the study. Therefore, only teachers who rated electric circuits to be difficult to teach were considered.

These teachers were teaching grade 12 with a minimum experience of three years. From the teachers who rated the topic of electric circuits to be a difficult topic to teach, only four were persuaded to participate in the study, with one of the four teachers used for a pilot study. It was important to collect data using this questionnaire because it assisted the researcher to determine the extent to which participants held a particular attitude or perspective (Babbie and Mouton, 2001). Additionally, the questionnaire is very useful to obtain facts and opinions about a phenomenon from people who are informed on the particular issue. The questionnaire also awarded the researcher with the opportunity to cover a large number of the participants with little time and cost. To ensure that the questionnaire was simple and informative, the researcher requested his supervisor to assist in order to correct questions that may be ambiguous.

3.5.2 Data collection instruments

3.5.2.1 In-depth semi-structured interviews

The researcher conducted four in-depth semi-structured interviews (Appendix B) with the selected teachers. Teachers were interviewed because it was hoped to get the richest data from them as these were the teachers who specified that the topic was difficult in the questionnaire. The aim of the interviews was to explore, understand and describe the teacher's knowledge, instructional strategies, interactions and discourse and accountability in the science classroom. According to Greenstein (2003), in-depth semi-structured interviews involve a clear list of issues to be addressed and questions to be answered but there is more flexibility around the sequence in which they are asked and the interviewer can allow participants to speak more broadly about the topic being discussed.

Berg (2007) strongly recommends that social researchers who intend to collect data using in-depth semi-structured interviews use a checklist. The checklist guides the researcher to ask questions related to the study and ensures that it is within the boundaries. Furthermore, the researcher divided the checklist into four sections.

Section A focuses on teacher knowledge. This section gathered teacher's knowledge with a specific focus on content knowledge. Here the aim was to collect the organisation and amount of subject matter knowledge, what teachers themselves understand about the topic. McDermott (2006) advocates that teachers need to understand the topics they are going to teach at a deeper level. The second focus was on contextual knowledge. It is important to understand how well the teacher knows the contextual factors such as number of learners in the classroom, time, socio-economic background and linguistic abilities. This is the advice that can be drawn from Lee (2005), who indicates that teachers need to have knowledge of the linguistic abilities of their students to enhance meaningful learning. It is of paramount importance to explore how teachers overcome language barriers if there are any. Lastly, the students understanding is focused on. The literature reviewed revealed that prior knowledge and misconceptions can affect teaching and learning. It was because of that reason that the checklist also probed teacher's awareness about prior knowledge and misconceptions about electric circuits. Interviews also helped to uncover this information because unlike the questionnaire and observation it allowed the researcher to rephrase and simplify the questions that the interviewee found difficult to understand. It was also pertinent to capture narrative data, people's description of their linguistic behaviours (Paylenko, 2007).

Section B is aimed at understanding what teachers actually do when they teach and how they teach it. Mudau (2013) clearly reports that what teachers do when they teach particular subject matter knowledge is fundamental to student learning. To investigate what Shulman (1987) called pedagogical content knowledge is key. Pedagogical content knowledge as explained by Shulman (1987), involves knowledge of how to teach particular subject matter knowledge. Problems, and issues can be organised, presented and adopted to the diverse interests and abilities of learners and presented for instruction.

Guided by Magnusson et al (1999), who reported that a teacher can have the best content knowledge but if they do not have the best explanatory frameworks to teach the content it is a futile exercise. The interviews explored the explanatory frameworks. Secondly, to gain a better insight of what causes teaching difficulties, the didactic perspectives were also probed. Kuzniak and Rauser (2011) indicate that some teaching difficulties arise from the didactic perspectives. Thirdly, activities in a physical science classroom can facilitate teaching and learning. It is important to understand how teachers use activities to promote learning. Finally, teachers can teach in a particular way based on how they believe knowledge can be constructed, a term called epistemology. According to Kalman (2009), epistemology should play an important role in science teaching. Therefore, gaining an insight on the epistemological perspectives is also the focus of the interview.

According to Scott (1998), it is not only activities that physical science teachers bring to the classroom to facilitate learning that make students learn but teacher-student talk around the activities and subject matter knowledge also influences learning. Additionally, science teaching is the act and art of teaching students to develop problem solving and inquiry skills. To achieve this objective teachers should teach their students using different strategies. These strategies include, amongst others, inquiry, conceptual change, discovery and didactics approaches.

Interactions and discourse in the science classroom between the teacher and students is fundamental to learning because it is central to meaning making (Scott, 1998). Mudau (2013) reports that the teaching of science can be difficult or effective, stemming from the kind of discourse the teacher uses. Therefore, section C of the interview checklist focuses on the type and pattern of discourse, communicative approaches and teacher questioning from the viewpoint of the teacher.

Section D deals with accountability. The main aim is to explore how the need to complete the syllabus and topics at given times shapes their teaching methods. Mudau (2013) reports that some teaching difficulties are as a result of the specific accountability that the teacher focuses on in the classroom. Three types of accountability were explored in this section, namely accountability to the system, accountability to the subject and accountability to the students. Moreover, the Department of Basic Education has introduced progressed learners. These are learners that are passed to the next grade without meeting the requirements. It is important to understand how teachers assist progressed learners who have a content gap but at the same time ensuring that they follow the Annual Teaching Plan (ATP) or the work schedule. These are documents provided to schools by the district officials to follow when teaching. It guides the teachers on what to teach and when to teach a particular topic. Interviews allowed the teachers to speak about these issues freely because as Sawell (2001) points out, interviews attempt to understand the world from the participant's point of view, to unfold the meaning of people's experiences and to uncover their lived world prior to scientific explanations. It also gives a holistic snapshot as to whether teachers are teaching for examinations or teaching to create scientifically developed learners.

3.5.2.2 Observation

Interviews alone are an insufficient form of data (Walford, 2017). To make the findings as robust as possible, the researcher also observed teachers teaching electric circuits in grade 12. The aim was to explore, understand and describe what the teachers were doing in the science classroom when teaching the topic. It was important to explore "What", "How" and "why" teachers do what they do when they teach topics they perceive to be difficult to teach. Observation is a fundamental and highly important method in all qualitative inquiry (Marshall, 2006).

Through observation, the researcher was able to see, hear and experience the same reality the teachers do. The aim of the study is to explore the nature of classroom practices when teaching the perceived to be difficult topic using a CPDF. Thus, in order to achieve this, the researcher used an observational checklist with the four frames of CPDF, namely teacher's knowledge, instructional strategies, interactions and discourse and accountability. One can argue that the interviews covered all of these aspects, however the researcher strongly felt that it was important to observe as well because observations can be of facts (Cohen et al. 2001), it can be used to capture non-verbal behaviour and behaviour in a natural setting, the classroom (Bailey, 1994). It also allowed the researcher to capture data which was taken for granted or might have gone unnoticed during the interviews (Cooper and Schindler, 2001) and lastly it assisted to triangulate the data from interviews. This was important because what people do may differ from what they say they do, and observation provided a reality check (Robson, 2002).

Frame A of the checklist deals with the teacher knowledge frame. This frame assisted to answer the first research sub-question that attempts to understand the nature of teacher's knowledge, how the teacher develops their lesson. The researcher was able to count the number of learners himself to verify the number given through interviews and how the teacher used language to help learners make meaning to learning. Observation assisted the researcher to understand how the teacher assessed prior knowledge and corrected misconceptions with scientific meanings. Marshall (2006) indicates that observation offers the researcher the opportunity to learn directly from their own experience.

Frame B focuses on the instructional strategies employed by the teacher. This frame explores the second research sub-question. The researcher identified the explanatory framework, epistemological perspective, activities and the didactics used in the classroom. This enabled the researcher to understand how the instructional strategies used shape interaction and discourse.

Frame C probes interactions and discourse. According to Bless et al (2015), observation permits the researcher to record the way in which interactions start and end. Additionally, it can focus on events as they happen. While the teacher is teaching they were asking and responding to learners in particular way. It is then that the observer was able identify the types and pattern of discourse, the communicative approach and the teacher questioning used. Unlike in the interviews where the researcher could only hear what the teacher said, observation allowed him to see and experience what the teacher was doing.

Lastly, frame D identifies the type of accountability the teacher responded too. Accountability in this study was divided into three categories, namely accountability to the system, accountability to the subject and accountability to the student. The focus here was to find out the type of accountability the teacher was answering too. Accountability to the system entails teaching to complete the syllabus and teaching for examination while accountability for the subject entails teaching for meaning making of concepts and teaching for understanding.

3.6 RIGOUR

3.6.1 Internal validity and field preparation

Internal validity was achieved by ensuring that the findings were derived from data collected from the study only (Maxwell, 1992). Interpretations were solely based from the teacher's point of view. The interviews were transcribed verbatim while in observations the researcher gave a detailed, descriptive note taking of events that he observed (Bekker, 1970). Proper communication took place between the researcher and the participants. They were constantly reminded about the dates and times of the interviews and observation. Ethical issues such as voluntary participation were discussed. After the University (UNISA) approved my ethical clearance, permission to access the province, District, School and classrooms was requested. This was done by writing request letters to the authorities in advance before fieldwork was done.

3.6.2. Pilot study

According to Bericer (2003), a pilot study is a procedure for testing and validating an instrument by administering it to a small group of participants from the intended test population. Teachers who perceive electric circuits as a difficult topic to teach are the intended population. From the four identified teachers, one teacher was used to pilot the study. Here the main goal was to refine aspects of the study. It was important to conduct a pilot study because it helped the researcher to orientate himself to the study. It also assisted to identify errors. The results of the pilot study were discussed with the supervisor to ensure that the selected procedure is workable. McBurney (2001) warns that researchers should never start the main inquiry unless they are confident that the chosen procedures are suitable, valid, reliable, effective and free from problems and errors, or at least that they have taken all possible precautions to avoid any problems that might arise during the study (Sarantakos, 2000). Thus, the pilot study helped the researcher to use the conceptual framework. It has helped to rephrase and eliminate leading questions.

3.7 TRUSTWORTHINESS

In qualitative research, the researcher, as a self-critical, thoughtful, curious and trustworthy human being, is the instrument through which the world is studied (Bless, Higson-Smith, and Sithole, 2015). According to Lincoln and Guba (1985), trustworthiness is divided into credibility, transferability, dependability and confirmability. The researcher observed the four categories of trustworthiness in the following manner:

3.7.1 Credibility

Credibility refers to the accuracy with which the researcher interpreted the data that was provided by the participants. It is increased by making use of triangulation, whereupon more than one research method (such as interviews combined with observation) are used to collect data (Shenton, 2004). As indicated in the data collection techniques, interviews and observation methods were employed by the researcher to increase the credibility of the research. The researcher never at any given stage of the research falsified any information. According to Du Plooy-Cilliers et al (2014), falsifying information is when a researcher deliberately fabricates or changes data to get a desired outcome or to avoid difficult, time consuming aspects of data collection and analysis etc.

3.7.2 Transferability

Transferability is the ability of the findings to be applied to a similar situation and deliver similar results. The researcher provides a detailed description of the context in which the data was collected. When the context from which the findings emerge is deeply understood, several other contexts where such findings might be meaningful can be imagined, then we can speak of a study having high transferability (Bless, Higson-Smith, & Sithole, 2015).

3.7.3 Dependability

Dependability refers to the quality of the process of integration that takes place between the data collection method, data analysis, and the theory generated from data (Lincoln and Guba, 1986). The researcher ensured that the findings are derived from the data collected only.

3.7.4 Confirmability

Confirmability refers to how well the data collected supports the findings and interpretations of the researcher. It requires the researcher to have described the research process fully in order to assist others scrutinising the research design (Lincoln and Guba, 1985).

The process has been explained such that other researchers may precisely understand what was done, why it it was done and in what context it was done so that they are able to replicate this work in other contexts and predict if and how the results might be different

3.8 DATA ANALYSIS AND INTERPRETATION

At this stage the researcher has sampled the participants, fieldwork has been concluded, which included collecting data through interviews and observations. The researcher had to analyse the collected data. According to Cohen et al (2011), Qualitative data analysis involves organising, accounting for and explaining the data. In short, making sense of data in terms of the participants' definitions of the situation, noting patterns, themes, categories and regularities.

The aims of analysing data were to describe what teachers do in the classroom and to clearly identify the conditions in which these actions take place. Firstly, data collected from the interviews and observations was transcribed. Transcribing had to do with transposing the spoken words into text. As stated earlier, data from interviews was audio-taped. Transcribing offered the researcher the opportunity to transpose audio-taped data to text. To ensure that the original meaning was not lost the transcribing was verbatim. Verbatim means the exact words of the speaker (word for word) were used. To ensure that the researcher is familiar with the date for the purpose of interpretation and analysis, the original interview of the completed verbatim transcription was listened to multiple times. The respondents were asked to listen to the audio and read the transcribed data to verify if the intended meaning is captured correctly.

After the transcriptions and translations, the coding process took place. Codes are names or labels assigned to specific units or segments of related meaning identified within the field notes and transcripts (Neuman, 2011). The classroom practices diagnostic framework (CPDF) units was used for coding, whic is made up of the teacher knowledge, instructional strategies, interactions and discourse and accountability. It will be easy to code using the segments against the conceptual framework because both the interview and observation tools were designed to address the segments of the CPDF. To ensure that the coding process became a success, three steps as listed by Neuman (2011) were followed, namely:

- Open coding: here the aim was to use the research topic, research question conceptual framework, literature review and personal experience to identify and name of segment to code field notes and transcribe data.

- Axial coding: the researcher organised the categories and patterns.

- Selective coding: the research topic and question was used to scan all the codes that were identified.

While the researcher was coding, some ideas came. This is because the researcher himself is a science teacher and coding may bring new ideas. Thus, alongside coding the researcher also did memos. Memos, as defined by Miles and Huberman (1994), are the write up of ideas and their relationships as they strike an analyst while coding. Since this process happens simultaneously it demanded that the researcher did not wait for coding first and later to embark on memos. As the ideas came during coding the researcher stopped coding and did the memos. This was to ensure that the ideas were not forgotten.

Patton (2002) indicates that qualitative analysis transforms data to findings. Coding and memos allowed the researcher to reduce the volume of the data collected into manageable data. It was also because the data was voluminous (De vos, Strydom, Fouche' and Delport, 2011). The researcher reduced data through editing, segmenting and summarising. Of course, the main objective of data reduction was done by finding the themes, clusters and patterns (Miles and Huberman, 1994). It was important that while reducing data in qualitative analysis, the context not be stripped (Miles and Huberman, 1994).

Tellis (1997) correctly points out that case studies do not claim to be representative, but the emphasis is what can be learned from a single case. The study adopted three case studies as stated earlier, which allowed the researcher to collect and analyse data simultaneously. It was important to immediately analyse data after collecting to ensure that the meanings were not lost or forgotten (Coffey & Atkinson, 1996). Additionally, case studies allowed the researcher to keep separate records for each case. Each case was given a folder with a name (a pseudonym) to ensure that the data is not mixed. A USB flash drive that required a password to access was used as well as a disc as a backup. This was done to observe issues related to ethics.

Data presentation

Data was presented in a tabular format wherein themes and categories from the conceptual framework were inductively used to organise the data. It was important to use the themes and categories from the conceptual framework because it allowed the researcher to transfer raw data from interviews and observations onto the table. Additionally, the interpretations of data for meaning was reached through direct interpretations of the teacher's instances and aggression of instances and interpretation can be reached after aggregating instances from various themes (Hitchcock and Hughes, 1995). A summary of each case was made to allow the researcher to make meaning and sense of each category.

3.9 ETHICAL CONSIDERATIONS

Conducting research in an ethically sound manner enhances the quality and trustworthiness of the research. Punch (2000) indicates that data collection procedure is intractably linked to issues related to ethics. Before administering the questionnaire the researcher explained who they were and what the research study is all about. This is because Opie (2004) warns that if the intention of the study is for degree purposes only, then it is unethical to conduct it. Cohen et al (2011) also advises researchers to fully explain the issue of the research to improve the situation (the issue of beneficence). In the questionnaire, the participants were asked to use a pencil to write their names and contact details. This was done to enable the researcher to contact the participants who qualify for the study. The names and contact details were not revealed to anyone. This was to guarantee the participants of their confidentiality, anonymity and non-traceability in the research. To avoid bias the researcher did not indicate the topic of interest in the questionnaire.

To prevent any harmful effects of the research to the participants the interviews were conducted in the presence of only the Interviewer and Interviewee in a confidential location. Not only was the location confidential but it was also appropriate, non-stressful, non-threatening as well. Besides asking for consent to interview an interviewee, consent was also asked to audio-tape the interview. This is because some people may not feel comfortable being interviewed while audio-taped as well. Cohen et al (2007) states that interviews are considered an intrusion into respondent's private lives with regard to time allocated and level of sensitivity of questions asked.

During the Observations, teachers were encouraged to teach as if the researcher was not there. The researcher also stressed that pseudonyms will be used in the writing of the report. Most importantly, participants also signed a consent form, which included among other things the right not to be observed and or audio-taped.

The researcher briefed all of the participants about who the researcher was and what the research was all about, He indicated that participation in the research was strictly voluntary, and no coercion would be used on participants to participate in the study.

3.9.1 Gaining access

Bell (1991) advised that researchers should gain permission before conducting research in a target community. Thus, the researcher firstly applied for ethical clearance from the University of South Africa (UNISA). Secondly, after UNISA had granted permission the researcher also wrote a letter to the Gauteng Department of Education (GDE) to ask for permission to gain access to their districts. Thirdly, after GDE approved the request a letter was written to the Tshwane West District (DI5) to ask for permission to access the schools and teachers. During the workshops, the researcher asked the subject advisors to administer the questionnaire to the teachers to complete. Teachers who specifically marked electric circuits as a difficult topic to teach in grade 12 were persuaded to participate. This was not a problem because a very good working relationship with them was already established. The researcher wrote to the teachers first before the principals because it would have been meaningless if access was gained from the principals but teachers perceive the topic as easy to teach and/or refuse to participate. Lastly, a letter was written to the principals of ten teachers who agreed to participate and perceive the topic to be difficult. Although it was aimed to include three teachers in the main study and one as a pilot, the other teachers were kept as reserves should one or two participants decide to withdraw from the study.

3.10 CONCLUSION

In this chapter, the researcher started by giving an introduction of the research methodology and design appropriate to this study. The researcher also gave reasons for using qualitative and case study as the methodology and design of the study. The qualitative method underpinned by the interpretative paradigm was outlined in this chapter. Moreover, the issue of trustworthiness was explored. The data collection procedures, specifically interviews and observation were also discussed in this chapter. Finally, ethical issues were discussed. In the next chapter, the researcher presents and discusses the data and their findings.

CHAPTER 4:
DATA PRESENTATION, INTERPRETATION AND DISCUSSION

4.1 INTRODUCTION

In this chapter, the data collected will be analysed in order to reach a better understanding of teachers' classroom practices used by science teachers when teaching electric circuits in grade 12 in the Tshwane west district. Three teachers, who will be named by their pseudonyms, were interviewed and thereafter observed presenting lessons in electric circuits. They are Mr Phakama, Mr Dakalo and Mr. Tebogo. The Classroom Practice Diagnostic Framework (CPDF) is used to analyse the data and to come up with answers to the research questions.

4.2 CASE 1: MR PHAKAMA

4.2.1 Data presentation

This section presents the data of the study

The following table gives the key words:

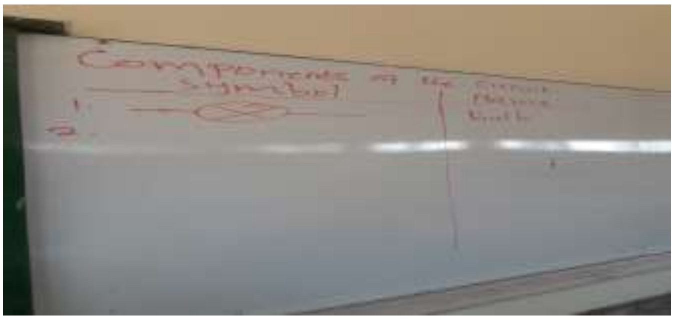
KEY WORDS		
Words	**Symbol**	**Explanation**
Prior Knowledge	PK	Knowledge required to learn electric circuits
Sequencing Ideas	SI	Sequencing of ideas to teach electric circuits
Content Knowledge	CK	The information the teacher teaches and expects learners to understand
Subject Matter Knowledge	SMK	Knowledge the teacher uses to assist learners to learn content in a meaningful way

A Teacher knowledge

Table 1.1 below presents Mr Phakama's knowledge and such knowledge comprised of the following categories, namely content, context and learners' understanding. The three categories consist of several characteristics as shown in the table below.

Table 1.1: Teacher knowledge (Mr Phakama)

Theme	Category	Characteristics
Teacher knowledge	Content knowledge	• **Mr Phakama:** "Series and parallel networks are usually about potential difference and current, so when we say we have a parallel connection of

<table>
<tr><td></td><td></td><td>devices we are going to say that it's a connection in which the parts connected have the same potential difference. Series network devices are connected in such a way that devices they have the same current, here if you connect an ammeter in any point you will find that the current is the same." (amount of SMK)
• Mr Phakama: the components of electric circuits are important; I remember something called light bulb. What other components do you know? (initiation, authoritative, PK)
• Mr Phakama: I will sketch the symbol of a light bulb (initiation, authoritative, subject matter knowledge)

• Mr Phakama: Anyone to sketch another symbol and write its name? (SI, PK)
• Learner 1: switch (answer)
• Researcher: Mr P wrote resistors in series and sketched the diagram below

• Mr Phakama: resistors in series, resistors connected in series receive the same current. It means that R_1 will receive the same current as R_2. (Organisation and amount of SMK).
• Researcher: P wrote the equation $I_T = I_1 = I_2$ on the board. He made an example that if the total current supplied is 2A, then R_1 will receive 2A and R_2 will receive 2A. (Content Knowledge)</td></tr>
<tr><td></td><td>Context</td><td>• Mr Phakama: "I'm going to start with electric circuits, doing grade 10 and 11 revisions, to check whether they still remember them. Will talk about connections, how voltmeters and ammeters should</td></tr>
</table>

		be connected and then we will touch a bit on ohms' law as well as ohmic and non-ohmic conductors." (topic to be taught) • **Mr Phakama**: "Some of them are from squatter camps, some are from around here and some of them are orphans. Therefore, its child headed families. Some of them are from divorced families." (socio-economic background) • **Researcher**: Which languages do your students speak? • **Mr Phakama**: "All students are Tshwana speaking people." (linguistic abilities) • **Researcher**: What resources do you have in your classroom that helps you teach the topic? • **Mr Phakama**: "We are using a smart board; it enables us to have or to demonstrate a video science demonstration of experiments that are done at a lab. We also have in position a physical lab which I think can also assist as well, but here we have a problem with lack of apparatus then we make use of videos to ensure that we are able to show them what to do." (resources to be used during the lesson) • **Researcher:** How long is your period, and how many do you have today? • **Mr Phakama:** "Our periods are 30 minutes long, so today I have a double period which means I have an hour." (time available) • **Researcher:** What is your classroom size? • **Mr Phakama**: "Maximum 35 learners in a classroom, we have small classes even if we wanted to accommodate more we cannot because it will reach carrying capacity." (class size) • **Mr Phakama**: "According to me the time should be increased because there are a lot of things to be covered and you should teach them to understand." (knowledge of the curriculum)
	Student understanding	• **Mr Phakama:** "They need to know components of a circuit both visually and symbolically, know how those components should be connected in a circuit that is the prior knowledge, they should also know and master ohms' law and they should know and master factors affecting resistance and the relationship between resistance, voltage and current. They should also know how to work with

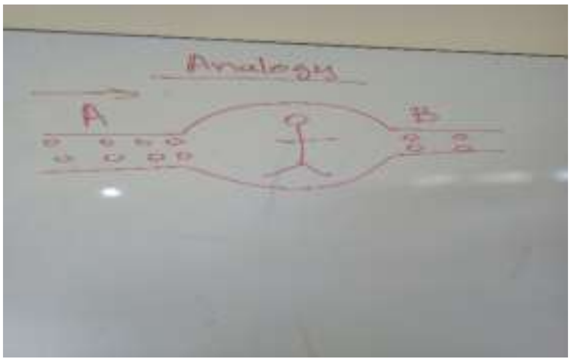
		graphs to say when potential difference changes then the current changes as well, what is the relationship between the two. We can write it down symbolically, we can also write it down in words stating ohms' law and we can write it down graphically. The same law can be interpreted in three different ways, they should know how to interpret it in three different ways and they should also have knowledge in working with series and parallel networks because I believe high school circuits from grade 10 to 12 are about series and parallel networks." (prior knowledge) • **Mr Phakama:** Because of the fact that learners do not understand how to deal with series and parallel networks. That is their problem. They do not know how to apply the knowledge they have on series and parallel networks. Say for an example if you are given two resistors in parallel and one in series with the parallel resistors, so you have a Parallel-Series connection. Now learners will not pick up that the resistors that are in parallel will have the same potential difference and if you add that potential difference with the one connected in series with the parallel connection, then it, should give you the total external voltage or potential difference. Most of them will add the two, and will see that the resistors in parallel have the same potential difference but then in terms of the total they add the two in parallel together with the one in series. Now they find out that the value is now bigger than what the battery is actually supplying." (misconception) • **Mr Phakama**: "They are very much interested. They know that when they get to grade 10 and start doing physical sciences, they are going to do interesting things."(learner interest)

B. Instructional strategies

Presented below are Mr Phakama's instructional strategies comprised of the following categories, namely teaching methods, explanatory framework and activities. The three categories consist of several characteristics as shown in the table below.

Table 1.2: Instructional strategies (Mr Phakama)

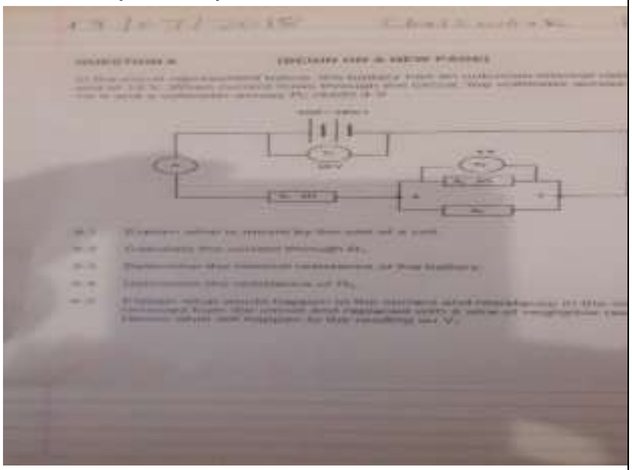
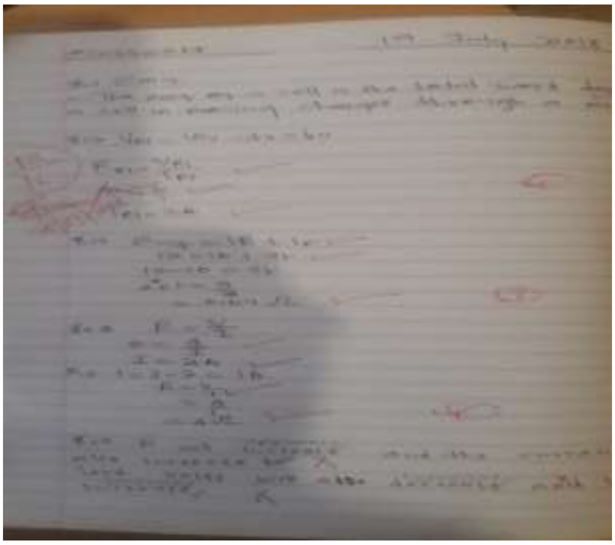
<table>
<tr>
<td>Instructional strategies</td>
<td>Explanatory frameworks</td>
<td>

Researcher: Representation includes amongst others: examples, models, analogies. Which one do you use during the lesson?
Mr Phakama “I have already explained some of these questions. I use models as they are of paramount importance to science teaching and learning. Here learners are able to see what I am talking about. I also use analogies in electric circuits, more especially when I explain the concept of resistance and current in parallel connection.” (method used during the lesson)
Mr Phakama: Resistance is defined as a n opposition of charges or current to flow (authoritative, SMK, analogy) See picture below


Researcher: Demonstrated how the analogy relates to the resistance. (making learning accessible to learners)
Mr Phakama: Unlike in series connection where the current is the same in the connected resistor, in parallel connection the current obeys the Kirchhoff’s current law. This law deals with the conservation of charge entering and leaving the junction. Here (referring to the analogy) the 5 Litres entering the junction will be divided according to the opening. The greater the opening the greater the amount of liquid it draws, however at the end of the junction the same of the three opening must give us 5 Litres. You must be careful here because

</td>
</tr>
</table>

		when we deal with electric circuit the explanation differs at bit, because the greater the resistance the lower the current. It means that the resistor with greater resistance will receive the smaller current. (organisation and amount of the SMK, illustrations, making learning accessible to learners) see picture below  
	Activities	• **Mr Phakama:** “We are using a smart board; it enables us to demonstrate a video science demonstration of experiments that are done at a lab. We also have in position a physical lab which I think can also assist as well, but here we have a problem with lack of apparatus then we make use of videos to ensure that we are able to see the experiment.” (learners watching an experiment on a smart • board) see picture below  • **Mr Phakama**: The teacher distributed the below activity to the learners.

		• **Mr Phakama**. We you give them activities because we want to drive a concept home and we want them to inquire more. How are they going to inquire more if we don't give them activities?" (Reason for giving activities). See picture below  **Researcher**: learner controlled book. See picture below 
	Didactics	• **Mr Phakama:** "For an example I will be teaching electric circuits where I will be engaging with the learners in direct instruction which is part of the didactic. From there learners will inquire about what is happening within that specific topic and from that inquiry they get to discover some of the things on their own because they made inquiry and there were didactic principles that were applied in teaching like direct

		instruction. (teaching methods during the lesson) • **Mr Phakama**: "Lecture method in isolation cannot solve anything especially in the teaching of science, it cannot work. It must be incorporated with other methods such as discovery, inquiry and conceptual change." (Teaching methods during the lesson). • **Mr Phakama**: ''At home we have electric circuits where we connect stoves and light bulbs, those are connections within a circuit and for that to happen we need a source, at homes we are supplied by Eskom as a source but for I cell phone I have a battery". (Direct story telling method used to grasp learner's attention and interest) • **Mr Phakama**: Resistors in parallel connected in parallel receive the same potential difference. (lecture method used during the lesson)

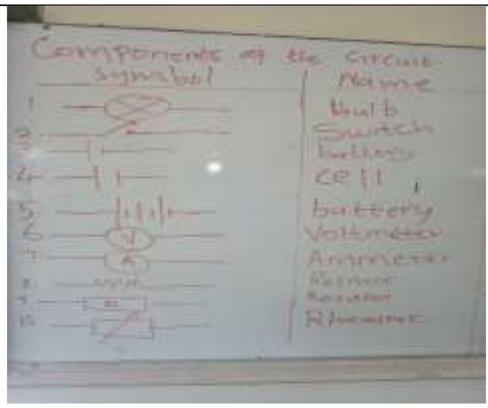
C. Classroom interactions and discourse

Table 1.3: Classroom interactions and discourse (Mr Phakama)

The table below presents Classroom interactions and discourse comprised of the following categories, namely types of discourse, patterns of discourse and teacher questioning. The three categories consist of several characteristics as shown in the table below.

Table 1.3: Classroom interactions and discourse (Mr Phakama)

Interactions and discourse	Types and pattern of discourse	• **Mr Phakama**: Potential difference in parallel connection is the same. (initiation-authoritative) • **Mr Phakama**: What other components of a circuit do you know? (interactive-authoritative) • **Learner**: Battery (response) see picture below (no 3)

		 • **Mr Phakama**: Is he correct? (interactive-authoritative) • **Learners**: No (response) • **Mr Phakama:** Why? (interactive-dialogic) • **Learner:** Because in grade 10 you taught us that, a battery has two or more cells, that one (pointing at the board) is a cell because it is one. (response)
	Teacher questioning	• **Mr Phakama**: What does the ohm's law state? (evaluative) • **Mr Phakama**: Ohmic conductor obeys ohms' law, what about non-Ohmic law? (lesson development) • **Mr Phakama**: What happens when you try to change a light bulb that has just burnt out? (lesson development) • **Mr Phakama**: Is a bulb Ohmic or non-Ohmic? (evaluative) • **Mr Phakama**: Is nichrome wire ohmic or non-ohmic? (evaluative) • **Mr Phakama**: At homes, we appliances connected ne…. are they connected in parallel or in series? (lesson development) • **Mr Phakama**: Do you know the total supply that goes to our homes? (lesson development)

	Communicative approach	• **Mr Phakama**: At homes, we use parallel connections, why do we use parallel connection at home? (initiation-interactive) • **Learner:** Because even if one components break the others continue working. (response-interactive) • **Mr Phakama**: That is correct (interactive-authoritative). • **Mr Phakama**: What are the factors that affect the resistance? (interactive-authoritative)

D. Accountability

Table 1.4: Accountability (Mr Phakama). The table below presents teachers' accountability comprised of the following categories, namely types of accountability. The three categories consist of several characteristics as shown in the table below.

Table 1.4: Accountability (Mr Phakama)

Accountability	System	• **Mr Phakama**: "I teach learners to understand and if they understand then they will pass examinations." • **Mr Phakama**: "I will tell the advisor that I am not teaching annual plan, I am teaching physical sciences. If you want to see the results come when they write June and final examinations, and check whether they are going to pass or not."
	Subject	• **Mr Phakama**: "I cannot cover electric circuit in four hours because for me four hours is for introduction." • **Mr Phakama**: "I teach learners to understand and if they understand then they will pass examinations."
	Student	• **Mr Phakama:** Are the wires that we use for the light bulb have the same thickness as the ones from the poles to our homes?

4.2.2 Discussion and findings

Teacher's content knowledge refers to the amount and organisation of subject matter knowledge (SMK) in the teacher's mind (Mudau, 2013). Mr Phakama's subject matter knowledge (SMK) was under scrutiny. The SMK is important because it influences the ways in which the teacher represents and formulates the subject in a way that makes it comprehensible to learners (Shulman, 1986). Mr Phakama's lesson presentation was organised and he sequenced the concept in order for learners to comprehend. This was evident during teaching of ohmic and non-ohmic conductors. He discussed that ohmic conductors obey ohm's law and gave an example of nichrome wire while non-ohmic conductors does not obey ohm's law. He used a light bulb as an example of a non-ohmic conductor. The physical science grade 12-examination guideline indicates that learners should be able to state the difference between ohmic conductors and non-ohmic conductors and give an example of each. The teacher also used ohm's law to explain the shape of a graph of an ohmic conductor. The teacher explained that it is a straight line because the ratio of $\frac{V}{I}$ remains constant at a constant temperature. While explaining the shape of a non-ohmic conductor he indicated that the filament gets very hot with the rise in temperature, the ratio of $\frac{V}{I}$ or R increases and this will lead to the shape of the graph bending upwards. This is important because the Curriculum and Assessment Policy Statement (CAPS) (2011) demands that learner should be able to interpret graphs and state the conditions.

Additionally, he differentiated between series and parallel connections of resistors. Here, he first sketched a model of resistors in series with each resistor connected with a voltmeter and an ammeter. The purpose was to show the learners that the current measured by each ammeter is equal. Furthermore, the potential difference measured by the voltmeter in each is not the same, if the resistance in the resistor (1) is not the same as resistance in resistor (2). For parallel connection, he also sketched the model of resistors connected in parallel. Here, he also connected a voltmeter and an ammeter in each of the two circuits. He discussed that the voltmeters connected will measure the same potential difference with the ammeter measuring different currents, provided the resistances of resistor (r1) is not equal as resistor (r2).

Mr Phakama demonstrated adequate context knowledge. He knew the contextual aspects like resources in the classroom, socio-economic background, the curriculum, and the size of the classroom. For an example:

> ***Researcher**: What resources do you have in your classroom that helps you teach the topic?*
>
> ***Mr Phakama**: "We are using a smart board; it enables us to have or to demonstrate a video science demonstration of experiments that are done at a lab. We also have in position a physical lab which I think can also assist as well, but here we have a problem with lack of apparatus then we make use of videos to ensure that we are able to show them what to do."*

The teacher was observed using a smart board to demonstrate how the internal resistance affects the potential difference supplied to the circuit. This was helpful to the learners to understand the difference between the electromotive force and terminal potential difference. This was evident by the responses learners gave as the lesson progressed. Thus, the teacher's contextual knowledge helped him demonstrate the experiment. This is important because Mudau (2013) reports that teaching difficulties could be because of ignorance of using available resources that could enhance the comprehension of the subject matter.

The teacher's student understanding was adequate. This is so because the teacher introduced his very first lesson on electric circuits by first assessing learner's prior knowledge. This is important in science teaching because constructivists argue that learner's prior-knowledge should be a point of departure in teaching (Hammer, 1996; Smith, Di Sessa & Roschell, 1993). Mr Phakama did this by asking learners to name and give symbols of components of electric circuits. Prior-knowledge and experiences play a major role in learner's capabilities (Eryilmaz, 2002).

Additionally, Mr Phakama was aware of difficulties and misconceptions learners may have. It is important for the teachers to identify and correct misconceptions because if not corrected, they can interfere with the development of appropriate scientific views (Galgher, 2014). He also acknowledged that electric circuits can be difficult because of the prior-knowledge and misconceptions associated with the topic and how he would use analogies to correct some of the misconceptions, for example:

> ***Researcher:** "I see you ticked electric circuit as a topic you perceive to be difficult to teach, why do you perceive electric circuits as a difficult topic to teach?"*

***Mr Phakama**” P: Because of the fact that learners do not understand how to deal with series and that parallel networks. That is their problem. They do not know how to apply the knowledge they have on series and parallel networks. Say for an example if you are given two resistors in parallel and one in series with the parallel resistors, so you have a Parallel-Series connection. Now learners will not pick up that the resistors that are in parallel will have the same potential difference and if you add that potential difference to the one, which is connected in series with the parallel connection, then it, should give you the total external voltage or potential difference. Most of them will add the two, and will see that the resistors in parallel have the same potential difference but then in terms of the total they add the two in parallel together with the one in series. Now they find out that the value is now bigger than what the battery is actually supplying, so briefly, misconceptions and pre-knowledge makes the topic difficult to teach.*”

The teacher used his knowledge of content, context and student understanding to select the appropriate instructional strategies. This was evident when the teacher indicated that there is a lack of equipment in the laboratory and used a smart board to play a video that demonstrated the internal resistance of the battery. Furthermore, the teacher used analogies to correct misconceptions learners may have.

Table 1.5 : A summary of Phakama’s teacher knowledge

Content knowledge	Adequate organisation and subject matter
	Knowledge
Context knowledge	Adequate knowledge of knowledge of the
	Context
Student understanding	Appropriate knowledge of prior-knowledge
	and misconceptions

Instructional strategies

Instructional strategies include explanatory frameworks, didactics, and activities (Mudau, 2013). This was helpful to answer one of the research questions: How do the instructional strategies used by the teacher shape classroom interaction and discourse?

Explanatory Frameworks

Shulman (1987,7) defines pedagogical content knowledge as ‘’the ways of representing and formulating the subject that makes it comprehensible to learners, that is, the analogies, illustrations, examples, explanations and ideas that a teacher uses in lessons’’. Additionally, McNicholl (2007) indicates that the teacher’s use of explanatory frameworks is a very important aspect of the teacher’s pedagogical content knowledge. The explanatory framework entails analogies, models and or illustrations, which the teacher uses to make the learning of electric circuits accessible to learning (Mudau, 2013). Mr Phakama used analogies to illustrate the concept of resistance and current flowing in parallel and series connections. First, he sketched a wire with two sections, A and B. The wire has a person in between. There were eight electrons from section A moving towards section B. The person in between allowed only four of the electrons to pass through. Here, he referred to the person as a resistance. He then defined resistance as an opposition of charges to flow. Second, He used a pipe with three openings in the centre. The openings differed in size. He indicated that the opening with the bigger size would draw more liquid from the 5 litres approaching the opening. He also used Kirchhoff’s current law that deals with the conservation of current. He explained that the 5 litres approaching the three openings would add up to 5 litres after the opening. This water analogy has proven helpful to learners understanding of the current behaviour, especially in parallel connections (Pfister, 2004). According to Korganci, et al (2015) water circuits provide an excellent analogy to simple electric circuits. Mr Phakama perceives electric circuits to be difficult topic to teach because of its abstract nature (Gunstone, 2009). Mr Phakama was aware that the use of models and analogies can assist learners to access electric circuits because analogies are efficient in understanding abstract concept (Cutis & Relgeluth, 1983)

Mr Phakama also gave an example of 3Ω and 2Ω resistors connected in parallel. The model of the circuit supplied a total of 2A. He then invited learner reasoning by asking them to explain the split of the current. This supports the nature of science teaching which is to develop inquiry skills and thinking abilities of learners. It is so because the learners used their reasoning skills to respond to the question.

Didactic perspectives

Didactics include traditional teaching methods like lecture methods and demonstration methods, which the teacher uses during lesson presentation (Mudau, 2013). Mr Phakama used lecture methods, demonstrations, question, and answer methods. For example,

> ***Researcher**: What is your view on the use of lecture method as a teaching strategy in science?*
>
> ***Mr Phakama**: "Lecture method in isolation cannot solve anything especially in the teaching of science, it cannot work. It must be incorporated with other methods such as discovery, inquiry and conceptual change."*

The teacher's response shows that the teacher considers methods other than lecture methods in his representation. Mr Phakama used lecture methods for basic information and skills. Additionally, the teacher used the lecture method mostly at the beginning of the lesson when introducing the topic. Here he will state the characteristic of each circuit. For example the teacher sketched a model of a series connection with two resistors. He then explained that the resistors connected in series will receive the same current, the potential difference will differ and how to calculate the total resistance in series using $R_p = R_1 + R_2$. This method of teaching has the advantage of delivering large amounts of information to the learners in a short period (Berry, 2008). However, during lecture method, learners' retention of information is weak (Kola & Langehoven, 2015). Furthermore, this method is against the constructivist-learning viewpoint that calls for maximum interaction between the teacher and learners. This is so because lecturing is a one-way process with the teacher telling learners what to do instead of activating them to discover for themselves (2015).

Although Mr Phakama's lesson included lecture methods, he also used demonstration methods. In fact, the lessons were dominated by demonstration. For example, the teacher would explain how ohmic and non-ohmic conductors behave. He would then draw a graph of each conductor. He also gave an example of an Ohmic and non-Ohmic conductor. Additionally, the teacher gave an example of a circuit connected in parallel and show how to calculate the total resistance. For example, the teacher gave an example of:

> *Two resistors 4Ω and 2Ω are connected in parallel. Calculate the current in each resistor, if the battery supplies 6V to the circuit.*

The teacher showed how the current can be calculated in parallel connection using $I_T = I_1 + I_2$.The teacher also asked learners to predict which resistor will consume more current. According to De Jager (2016), demonstration is the process of teaching through example or experimentation. Moreover, demonstration, unlike lecture, improves learner's understanding and retention (Mckee, Willamson, and Ruebush, 2007).

Mr Phakama used question and answer methods for lesson development and to evaluate learner's prior knowledge. He asked learners about the components they learned from grade 10 and 11. For an example,

> ***Mr Phakama**: What other components of the circuit do you know?*
>
> ***Learner**: Switch*

Maeda & Abe (2010) indicate that teachers who use question and answer methods in their lesson are more successful in achieving lesson objectives than those who do not question. It is important for a teacher to ask questions that focus on learners interests because it helps the learners to understand new concepts more easily (Ito, 2010)

Activities

According to Mudau (2013), activities involve problems, demonstrations, simulations, investigations or experiments the teachers use to help learners comprehend the content. Mr phakama used class work, Homework and video demonstration to help learners comprehend the content. For example, in one of his presentations the teacher played a video demonstration of internal resistance to help learners comprehend the content. This was to improvise for the lack of apparatus in the laboratory. The learners watched how the internal resistance affected the potential difference to be supplied to the external circuit. This improvisation was necessary because in science, teaching strategies incorporating experiments are considered to be the most important educational tool in the science classroom, especially for teaching difficult or abstract concepts (Hofstein and Lunetta, 2004). The advantage of experiments is that it can link theory with practice. Furthermore, the researcher also checked with the teacher if the experiment was also done in the laboratory and the teacher indicated that it was done. It was done during member checking because the teacher was observed saying that the learners will perform an experiment on internal circuits. This is important because the CAPS prescribes electric circuit experiments, which are examinable in the grade 12 end of year examinations.

Table 1.6: A summary of Mr Phakama`s Classroom instructional strategies

<table>
<tr><td rowspan="6">Instructional strategies</td><td rowspan="4">Explanatory framework</td><td>Analogies</td></tr>
<tr><td>Models</td></tr>
<tr><td>Examples</td></tr>
<tr><td>Illustration</td></tr>
<tr><td rowspan="2">Activities</td><td>Classwork</td></tr>
<tr><td>Homework</td></tr>
</table>

		Experiment (via Smart board)
	Didactics	Lecture
		Question and answer
		Demonstrations

Interactions and Discourse

Students' learning in the science classroom primarily comes from the teacher talk and teacher-students talk (Chin: 2006). The teacher used an IRFRF pattern of discourse (Mortimer and Scott, 2003). This is because in most cases the teacher would initiate the discourse, in the form of question and answer method. He would invite learners to response to the question he posed. After the learners gave their responses he would further ask the class if the response given was correct or incorrect. Depending on the response, he usually asked learners to support their answers by explaining in detail. This type of discourse is unlike IRF that restricts learners thinking, instead it encourages responses from the learners' point of view (Mortimer and Scott, 2003). For example:

> ***Mr Phakama:*** *Is he correct? (interactive-authoritative)*
> ***Learners****: No (response)*
> ***Mr Phakama****: Why? (response-dialogic)*
> ***Learner:*** *Because in grade 10 you taught us that, a battery has two or more cells, that one (pointing at the board) is a cell because it is one. (Response)*

Mr Phakama asked questions to evaluate learner's prior-knowledge and understanding. Chin (2006) indicates that teacher questioning is prominent in science classroom discourse. In traditional lessons, the purpose of questions is for evaluation of what learners know. In addition, he would ask questions to develop the lesson. In the constructivist based or inquiry orientated lessons, teachers use questions to help learners construct understanding and generate meaning. When teaching ohmic and non-ohmic conductors the teacher would ask the learners questions related to their real life experiences. For example:

> ***Mr Phakama:*** *What happens when you try to change a light bulb that has just burnt out?*

This question allowed learners to use their real life experience to respond. It is important because the question offers the learners the opportunity to meaningfully engage with the subject matter and construct their own understanding (Chin, 2006). Although the question was evaluative in nature it was further extended upon to develop the lesson. Here, after learners indicated that the light bulb would be warm, the teacher indicated that it falls under non-ohmic conductors.

The communicative approach focuses on ways in which the teacher works with the learners to talk about ideas and concepts. The nature of the communicative approach was interactive but authoritative (Mudau, 2013). Chin (2006:1318) indicates, “For the interactive/authoritative communicative approach, the teacher invites responses from the students but discounts their ideas as he/she focuses solely on the scientific idea”. Mr Phakama, while teaching parallel and series connections, asked the learners the type of connections they use at homes. Learners responded differently with most saying parallel and one saying series. He then asked the one who said series to support his response by giving a reason. The learner was unable to support his response. The teacher then asked one learner who indicated that the appliances should be connected in parallel. The learner said that it is because if one component breaks the other components will continue to work. The teacher then indicated that it is not series because in series when one component breaks the whole circuit will stop working. Chin (2006) states that in an authoritative discourse the teacher conveys information and his utterances are often made up of instructional questions and factual statements. This was the case with Mr Phakama.

Table 1.7: Summaries of Classroom interactions and discourse employed in the lesson

<table>
<tr><td rowspan="10">Classroom interactions and discourse</td><td>Types of discourse</td><td>Authoritative discourse</td></tr>
<tr><td rowspan="5">Patterns of discourse</td><td>Initiation-teacher</td></tr>
<tr><td>Response- learner</td></tr>
<tr><td>Feedback –teacher</td></tr>
<tr><td>Response- learner</td></tr>
<tr><td>Feedback-teacher</td></tr>
<tr><td rowspan="2">Teacher questioning</td><td>lesson development</td></tr>
<tr><td>Evaluate the lesson</td></tr>
<tr><td>Communicative approach</td><td>Interactive-authoritative</td></tr>
</table>

Teacher accountability in the science classroom

Jita (2004) espouses three themes of accountability, which may shape the science teacher’s practice. There is the accountability to the system, subject and learners.

Accountability to the system

Mr Phakama did not focus on the examinations and the completion of the syllabus. He spent two hours of the four hours prescribed by the annual teaching plan doing revisions. In the pre-interviews he indicated that the time allocated to teach the topic is too little, he can use the time for only grade 10 and 11 revisions.

> ***Researcher****: How does the need to cover electric circuit in four hours shape your teaching?*
>
> ***Mr Phakama****: "I cannot cover electric circuit in four hours because for me four hours is for introduction."*

Therefore, Mr Phakama's accountability was not to the system. It is so because accountability to the system refers to the amount of content covered by the teacher to prepare his/her learners for the examinations (Jita, 2004:16).

Accountability to the subject

The teacher's focus on how his/her learners make meaning of concepts and their applications to the student's personal life (Jita, 2004) is the accountability to the subject. Furthermore, it highlights the instructional strategies and learning context designs that a teacher uses to facilitate conceptual comprehension (Jita, 2004). Thus, Mr Phakama's accountability was with the subject. It is so because the teacher stressed meaningful application of the subject. This was evident during the lesson because the teacher dominated his lesson with demonstration rather than lecture method, the use of analogies, models and examples to help learners access the content as well as the time spent doing activities that helped learners to comprehend the content. For example, during the interviews the teacher indicated that it important to teach the learners to understand because when they understand they will be able to apply their understanding in the examinations.

> ***Researcher****: When you teach learners, do you teach them to understand or for examinations?*
>
> ***Mr Phakama****: "I teach learners to understand and if they understand then they will pass examinations."*

Mudau (2013) indicates that from this accountability the explanatory frameworks, which the teacher uses to enable his /her learners to access the subject matter and make meaning as well as apply it, is of paramount importance to the teacher. Mr Phakama used the analogies to explain resistance and current in parallel connection. His intention was to help learners access the subject matter. The teacher also took his time to infuse prior knowledge from grade 10 and 11 without rushing to finish the syllabus.

Accountability to the learners

Accountability to the learners focuses on inclusivity (Jita, 2004). Mr Phakama's accountability was not to the learners. Even though the teacher was aware that all learners were Tshwana speaking learners for whom the language of learning and teaching is an additional language, there was no attempt by the teacher to code switch or paraphrase during teaching. According to Henderson and Willington (1988), a language barrier is the greatest barrier to learning science for many learners. This is important because inclusion implies that every learner can access and participate in successful education, regardless of gender, race, language, socio-economic background or disability (Ainscow, 2009).

Table 1.8: Summaries of Teachers accountability

Accountability	System	***Mr Phakama**: "I cannot cover electric circuit in four hours because for me four hours is for introduction."*
	Subject	Mr Phakama: "I teach learners to understand and if they understand then they will pass examinations."
	Students	Mr Phakama's was not accountable to the learners

4.3 CASE TWO (MR. DAKALO)

4.3.1 Data presentation

This section presents the data of the study.

The following table gives the key words:

KEY WORDS		
Words	**Symbol**	**Explanation**
Prior Knowledge	PK	Knowledge required to learn electric circuits
Sequencing Ideas	SI	Sequencing of ideas to teach electric circuits
Content Knowledge	CK	The information the teacher teaches and expects learners to understand
Subject Matter Knowledge	SMK	Knowledge the teacher uses to assist learners to learn content in a meaningful way
Incorrect Subject Matter Knowledge	ISMK	Inappropriate knowledge of the teachers to assist learners to learn the content

A. Teacher knowledge

Table 1.9 below presents Mr Dakalo's knowledge and such knowledge is comprised of the following categories, namely content, context and learners' understanding. The three categories consist of several characteristics as shown in the table below.

Table 1.9: Teacher knowledge (Mr Dakalo)

Theme	Category	Characteristics
Teacher knowledge	Content knowledge	• **Teacher:** "It becomes dimmer and dimmer. Why does it become dimmer? It is because of the type of connection. Ok, that type of connection, let's give it a name. Now, type of connection. Very important part now of you understanding electric circuits that by the time I'm going to finish this explanation, everything will be done at last. (Writes on board) Series Connection. We said something becomes dimmer and dimmer. Now when we represent a Series Connection, this is what, this is our type of (sketches a circuit on board) connection, akere? Ehrr... These are my resistors. Oh, kana it is caps, Eish! (Makes correction on sketch). I forgot, I'm sorry. In CAPS, according to CAPS document, I must make rectangles, neh? Those are my resistors. This is Resistor 1, this is Resistor 2 and that one is Resistor 3. Now because you have said that the light in it becomes dimmer and dimmer, we are going to make a conclusion that says, Vt, which is the potential difference at the house that is having the main power source, will be equals to the sum of those potential difference from the different houses. (Writes $Vt=V^1+V^2+V^3$ on board). (Initiation, unorganised subject matter).

- **Teacher:** Meaning the Resistor 1 will have a greater potential difference than Resistor 2 and Resistor 3 because you have said, according to Tembisa's connection, the light becomes dimmer and dimmer as we move far. Gona gore, when this potential difference is being lost, the bulbs are going to switch from far as we come closer to Resistor 1. Closer to the source power where we have energy. Akere?” (unorganised subject matter)
- **Teacher:** Therefore, the biggest current will pass through the smaller resistor. And the smaller current will pass through a smaller resistor. I’m repeating myself, because we agreed that this current is going to be divided according to the proportion of the resistors, therefore the bigger current will pass through the smaller resistor. Akere? Bigger current pass through a smaller resistor, and then……”(incorrect subject matter)
- **Learners:** “Small current pass through a bigger resistor.”
- **Teacher:** Because these people are the ones that are called charges and the rate at which these charges pass through is current. The smaller the door the bigger the resistance and it doesn’t allow many people to pass. The bigger the door the smaller the

		resistance. It allows many people to pass. It's the same thing that is there. (authoritative, incorrect subject matter) • **Teacher:** “The difference is that series connection, the current that is passing through a connection is the same throughout. And the potential difference across that connection is different. And then on parallel connection, the current that is passing there its divide according to the proportion of the resistors, and the potential difference on the parallel connection is the same. So that’s how I’ll explain the difference between the 2.” (initiation, authoritative, unorganised content knowledge) . • **Teacher:** Ehrr... These are my resistors. Oh, kana it is caps, Eish! (Makes correction on sketch). I forgot, I’m sorry. In caps, according to caps document, I must make rectangles, neh? (interactive, knowledge of the curriculum) • **Teacher:** “Ya. So the parallel connection would be this one (draws on board). This is the tricky part of electric circuits, neh? If you understand this tricky part, ah then….. Ah, no. Let me start with 2 (corrects drawing on board). Let me start with 2 then we go to 3 and 4 and so on. Eish! Now whatever I was said there, is vice-verse. The conclusion that was said on Series Connection is vice-verse. If you understand vice-verse. Anyone who can explain or say something about vice-verse of that? And put it there (pointing to the drawing on board). Yebo!”

	Context	• **Researcher:** "Oh ok. Thank you very much. Ehrr… what are you going to teach today?" • **Mr Dakalo:** "Electric circuits."(topic to be taught) • **Researcher:** "Ehrr. What resources do you have in your classroom that will help you teach the topic?" • **Mr Dakalo:** "I will be using textbooks, chalk board, previous question papers to prepare my lesson and present it." (available resources) • **Researcher:** "Ok thank you very much. Then tell me Mr Mawela, what is the socio-economic backgrounds of most of your learners in your school, the whole school and particularly in your classroom?" • **Mr Dakalo:** "It's that learners come from another province. They travel from long distance from North West come to Gauteng using different transport and they come from a very poor background. Ehrr… some children come from child headed family. Which contribute to teaching, you see?" • **Mr Dakalo:** "They contribute very bad because some of them they need psychologists to take them through the headed family backgrounds because it also affect to the teaching because most of them you find out that they are not concentrating in class. They are thinking about their problems more than the content, making it very difficult." • **Mr Dakalo:** "Ehrr… Normally, in our school, periods goes by 30 minutes and today I'm having 2 periods which will lead me to one hour." • **Researcher:** "Oh. Thank you, thank you very much. And then, ehrr, which

		language or languages do your learners speak?" • **Mr Dakalo:** "Ehrr.. Most of the time they speak Tswana. 90% of them its Tswana then the rest its other languages like Zulu, a little bit of Sepedi and others." • **Researcher:** "You have 40 learners?" • **Mr Dakalo:** "Yeah. Overcrowding as you can see (giggles)." (adequate context knowledge) • **Researcher:** "Oh ok. Thank you very much. Do we have learners doing Physical Science and Mathematical Literacy?" • **Mr Dakalo:** "Yes and those learners are not performing that very good, because there are some questions there, in Physical Science, that they need Mathematics concept such as calculations that involve simultaneous equation. And making subject of the formulas, it becomes a challenge to them."
	Student understanding	• **Teacher:** "Thank you. Now as these charges are going to move, there is different types of connection, akere? Ok, let's come out with another example, laitsi koTembisa? Those who know Tembisa or Alexandra, there's a type of connection that is happening there, izinyoka. So ya, because of izinyoka, pleke ela etshwereng the main power. Now when we are busy connecting from that house, to the other, what happens to the brightness of the light?" • **Learners:** "It becomes dimmer." (learner misconception) • **Teacher:** "It becomes dimmer and dimmer (teacher misconception) • **Teacher** "Ok. I am not going to define this law (underlining Ohm's Law on the

		board). I know you people are going to define this law because we have to interact. Let’s start, neh? I will just write the formula of Ohm's Law which is R = V/I (class in chorus). Can someone give is the definition please. Re nyaka babasaitsing. (Pointing at one of the learners). Bua ousi Lolo. Ok, babaitsing ke. (Learners burst in laughter).” (initiation, prior knowledge) • **Researcher:** “Alright! Thank you, thank you very much. Let’s go to student understanding, what prior knowledge do learners need to learn electric circuits that are in Grade 12?” • **Mr Dakalo:** “Ehrr… They need the Grade 10 and 11 knowledge of electric circuits which includes Ohm’s law, ohmic conductor, non-ohmic conductor, power and energies.” • **Researcher:** “Alright! Thank you, thank you very much. Let’s go to student understanding, what prior knowledge do learners need to learn electric circuits that are in Grade 12?” • **Mr Dakalo:** “Ehrr… They need the Grade 10 and 11 knowledge of electric circuits which includes Ohm’s law, ohmic conductor, non-ohmic conductor, power and energies.”(prior knowledge) • **Teacher:** “In a few seconds, I will just take you a little bit back because you did this in Grade 10 and all that. I will be concentrating in the following: (Writing on the board) you must know how to define Ohm’s law. After defining Ohm's law, that’s number 1, it’s very important. Number 2, you must know your connections in that electric circuits. Are we clear? You are going to differentiate our connection in the following which is (Writing on

		board) Series, Parallel and both, akere?"(prior knowledge) • **Researcher:** "Thank you. Thank you very much. And then do you know of any misconceptions learners might have and if 'YES' how do you correct them?" • **Mr Dakalo**: "I think the misconception behind these learners is that they think that the brightness of the bulb is controlled by current. Whereas in reality it's controlled by the potential difference that is supplied by the battery." • **Researcher:** "How would you correct that?" • **Mr Dakalo:** "By giving example of real life situation according to the way izinyoka is being connected to other areas. For example, Tembisa. And when we are talking about, even in class, the way these lights are connected. Because they are glowing in the same brightness, it simply tells about the potential difference that is there." (knowledge of student understanding, misconception) • Teacher: Now I want to show you how to calculate those things. Because I have talked about the word proportion from grade 10, you did what is called weak point theorem. They taught you about proportionality. The first thing that you need to do is to add the resistors. Step number 1 is to do what?" (authoritative, prior knowledge)

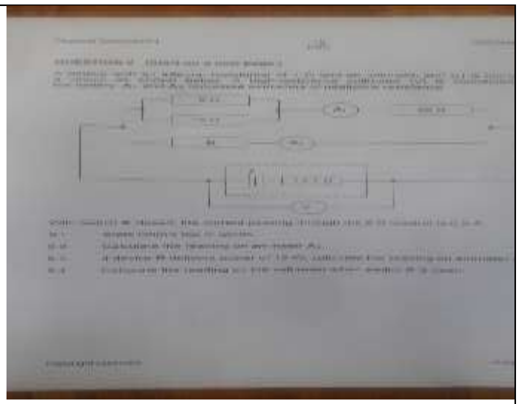
B. Instructional strategies

Table 1.10 Presented below are Mr Dakalo's instructional strategies comprised of the following categories, namely teaching methods, explanatory framework and activities. The three categories consist of several characteristics as shown in the table below.

Table 1.10: Instructional strategies (Mr Dakalo)

Instructional strategies	Explanatory frameworks	• **Teacher:** "And then you are all in here. Ko thella molilo at the back or there's a snake somewhere there. What will happen? We are all going to run through the…."(learners interest, interactive, analogy) • **Learners:** "Door." (response) • **Teacher:** "Ok. So imagine if we want to try to fit in the door, all of us ritswe. Are we there? What's gonna happen is that other people won't be able to go…"(interactive) • **Learners:** "Out."(response) • Mr Dakalo: "I have different analogies that I can use. I can make use of, when teaching electric circuits for example, by showing learners how to understand the resistance or the resistor part by giving them analogy either of water or of learners wanting to pass the door at the same time. When learners want to pass the door at the same time they don't be able to pass at the same time because the door doesn't allow many learners to pass the door at once. Then if it doesn't allow, it resists them from passing. Therefore, that's how I would introduce the topic of resistors."
	Activities	• **Researcher:** "Ok, thank you very much. Let us go to section B, the instructional strategies. The following are broad teaching strategies; the process, the

		diagram, discovery, activity driven enquiry and conceptual change. From these, tell me the ones you know and briefly talk about them." • **Mr Dakalo:** "Ehrr… Activity Driven. Because it's when I give learners the activities and learners do the activities and I drill them on those activities and I prefer them in Physical Science because Physical Science is a driven subject. You must drill these kids on the activities so that they get the concept." • **Mr Dakalo:** "I use demonstration because I demonstrate by giving them examples. Start by giving them notes then comes with examples then demonstrate different types of questions. How to answer them and how to approach those questions. Then that is why I prefer and use demonstration." • **Researcher:** "So when you drill these learners are you using the textbook questions or the examination questions?" • **Mr Dakalo:** "I use them both. I first start with the textbook, then lead to examination questions so that they can see the difference and how the question paper is set." • **Teacher:** "Oh, let's do November 2015. Oh you don't have it, it's fine. Let me just draw the diagram because we need to explain while looking at it. (see picture below)

		
	Didactics	• **Researcher:** "Ok. Thank you very much. What is your view on the use of lecturer method as a teaching strategy in Science?" • **Mr Dakalo:** "In our school I should say it is incorrect to use that strategy. Why should I say that because learners need to work so that they can see the different types of questions and know how to approach these questions on their own? If I'm the one who is doing the talking, then learners won't get to see the difference of the questions." • **Teacher:** "You don't calculate for total resistance but it just adding these two. When you want to calculate the total resistance for a parallel connection, it's 1/R equivalent or R external which is equal to $1/R^1 + 1/R^2$ please. Akere? We are not looking for such, we are talking about proportionality. We want to explain the part of current. Akere?" • **Teacher:** "Let me make this very clear because it can be a contradiction, it is NOT the total resistance, neh?"

B. Classroom interactions and discourse

Table 1.11: Classroom interactions and discourse (Mr Dakalo). the table below presents Classroom interactions and discourse comprised of the

following categories, namely types of discourse, patterns of discourse and teacher questioning. The three categories consist of several characteristics as shown in the table below.

Table 1.11: Classroom interactions and discourse (Mr Dakalo)

Interactions and discourse	Types and pattern of discourse	• **Teacher:** "And then you are all in here. Ko thella molilo at the back or there's a snake somewhere there. What will happen? We are all going to run through the…." • **Learners:** "Door." • **Teacher:** "Trying to go out, neh?" • **Learners:** "Yes." • **Teacher:** "Ok. But we cannot all fit in the…" • **Learners:** "Door."
	Teacher questioning	• **Teacher:** "The rate at which these charges are moving is called current. Are we here?" • **Learners:** "Yes." • Teacher: "Yes. It resists us. (Writing on the board) The door does what?" • **Learners:** (in chorus) "It resists us." • **Teacher:** Because it's very rare to do a mistake from what I know. Now, we have a 3 ohm there. Now if I can put any resistor there of 7, the current that is going to pass there, is 3. Are we clear? • **Learners:** "Yes." • **Teacher:** "The current that is passing there is what?" • **Learners**: "3"

	Communicative approach	• **Researcher:** "Thank you very much. Which pattern of discourse do you think you use amongst authoritative, dialogic and reflective?" • **Mr Dakalo:** "Dialogic. So that learners can engage and interact during the lesson. There must be an interaction and learners must engage themselves during a presentation." • **Teacher:** "Ok. I am not going to define this law (underlining Ohm's Law on the board). I know you people are going to define this law because we have to interact. Let's start, neh? I will just write the formula of Ohm's Law which is R = V/I (class in chorus). Can someone give is the definition please. Re nyaka babasaitsing. (Pointing at one of the learners). Bua ousi Lolo. Ok, babaitsing ke. (Learners burst in laughter)." • **Learner:** "The initial difference across a resistor, the magnitude….." • **Teacher:** "La motlwa o e libetse. She's writing tomorrow, the possibility of that definition coming in the exams, it's 99% chances. (Points at another learner)." • **Learner:** "The potential difference is directly proportional to the current."

		• **Teacher:** "But you are missing something. There's something that is missing." • **Learner:** "At a constant temperature."

D. Accountability

Table 1.12: Accountability (Mr Dakalo) the table below presents teachers accountability comprised of the following categories, namely types of accountability. The three categories consist of several characteristics as shown in the table below.

Table 1.12: Accountability (Mr Dakalo)

Accountability	System	• **Researcher:** "When, you teach learners, do you teach them to understand or for examinations?" • **Mr Dakalo:** "As I have said, I teach them to understand so that they will be able to approach any type of question and be able to master the subject and pass the examination. I don't teach for examination but to understand."
	Subject	**Researcher:** "Ok, thank you very much. Ehrr… What would you say to a subject advisor who says you are left behind with the annual teaching plan?" **Mr Dakalo**: "I will say, Sir, learners need to understand the content and the concept rather than rush to finish the ATP without understanding. That would result in 0% pass rate. So if they understand, they would rather be behind but all the questions that they will answer will be correct."
	Student	**Teacher:** "Thank you. Now as these charges are going to move, there is different types of connection, akere? Ok, let's come out with another example, laitsi koTembisa? Those who know Tembisa or Alexandra, there's a type of connection that is happening there, izinyoka. So ya, because of izinyoka, pleke ela etshwereng the main

		power. Now when we are busy connecting from that house, to the other, what happens to the brightness of the light?" **Learners:** "It becomes dimmer." **Teacher:** "It becomes dimmer and dimmer. Why does it become dimmer? It is because of the type off connection. Ok, that type of connection, let's give it a name. Now, type of connection. Very important part now of you understanding electric circuits that by the time I'm going to finish this explanation, everything will be done at last.

4.3.2 Discussion and findings

The content knowledge of the teacher, that being the amount and organisation of subject matter knowledge in the mind of the teacher with a focus on electric circuits, was under scrutiny (Mudau, 2013). This is important because teacher's content knowledge can influence what the teacher teaches and how he/she teaches it (Yilmaz-Tuzun, 2008). Mr. Dakalo's amount of subject matter knowledge was adequate but organisation of subject matter knowledge was not. This was noted while he was teaching electric circuits, series and parallel connections. For example:

We said something becomes dimmer and dimmer. Now when we represent a Series Connection, this is what, this is our type of (sketches a circuit on board) connection, akere? Ehrr... These are my resistors. Oh, kana it is caps, Eish! (Makes correction on sketch). I forgot, I'm sorry. In CAPS, according to CAPS document, I must make rectangles, neh? Those are my resistors. This is Resistor 1, this is Resistor 2 and that one is Resistor 3. Now because you have said that the light becomes dimmer and dimmer, we are going to make a conclusion that says, Vt, which is the potential difference at the house that is having the main power source, will be equals to the sum of those potential difference from the different houses. (Writes $Vt=V^1+V^2+V^3$ *on board).*

The teacher demonstrated that the potential difference in series is divided according to the proportionality of the resistors. He showed this by using the formula Vt=V1+V2+V3, that was the case with the current as he used It=I1+I2+I3. However, the teacher did not indicate where I1, I2 and I3 are connected. He also did not show where V1, V2 and V3 are connected in the circuit. Ideally, the teacher should have connected I1 and V1 in the resistor R1, I2 and V2 in resistor R2 and also I3 and V3 in resistor R3. This could have made it easy for learners to see what I1, I2 and I3 are measuring. Additionally the curriculum demands that learners should be able to calculate the total resistance in series using

Rs=R1+R2+R3 and in parallel connection using 1/R=1/R1+1/R2+1/R3. Mr. Dakalo did not teach the learners to calculate the total resistance in series connection. Therefore, the organisation and total amount of subject matter knowledge of Mr Dakalo was inadequate.

Mr Dakalo demonstrated adequate context knowledge. Context knowledge refers to contextual factors such as the available time, socio-economic background, resources available, progressed learners, linguistic abilities and the classroom size (Mudau, 2013). The teacher was aware of the socio-economic background of the learners and his classroom size. For example,

> ***Researcher**: "Ok. Thank you very much. Ehrr… How long is your period and how many do you have for today?"*
>
> ***Mr Dakalo**: "Ehrr… Normally, in our school, periods goes by 30 minutes and today I'm having 2 periods which will lead me to one hour."*

He also acknowledged the consequences of progressed learners in the classroom in that he indicated that they have a content gap from grade 11 that needs to be closed first before teaching the topic. However, the teacher did not teach any grade 11 content before teaching electric circuits in grade 12. Mr Dakalo's knowledge of students' understanding was inadequate. Knowledge of student understanding entails prior knowledge and removing misconceptions that learners might have. According to Pfundt and Duit (2006), learners come to the classroom with preconceptions which were formed during their interaction with the physical and social environment and those preconceptions affect learning. It follows then that the teacher should assess and correct those preconceptions that learners bring into the classroom before teaching a topic. This was not the case with Mr. Dakalo. For example, although Mr Dakalo knew that learners should be able to state Ohms law and to understand the behavior of ohmic and non-ohmic conductors from grade 11, the teacher did not assess ohmic and non-ohmic conductors. Additionally, he did not check if learners still remembered the components of electric circuits or not. This is important because according to Metloui et al (2016), teaching that does not start from the learners' point of view cannot arouse in them active involvement, which is indispensable for the complex process of constructing scientific thought. In addition, some of those ideas that they bring into the science classroom are in contradiction with scientific knowledge and create problems in learning, a term called misconception.

There are many misconceptions in electric circuits (Driver and Bell, 1986) and some of them may deeply penetrate into learners minds and resist change despite teaching (Stanton, 1990). Learners thought that the further away the bulb is from the battery the dimmer the bulb will be (Shipstone, Jung and Dupin, 1988). This misconception was encouraged from the teacher, who also believed that the light bulb near to the power source will be brighter than the one further away. However, the teacher contradicted himself because he knew that the brightness of identical bulbs depends on how they are connected. For example,

> *Meaning the Resistor 1 will have a greater potential difference than Resistor 2 and Resistor 3 because you have said, according to Tembisa's connection, the light becomes dimmer and dimmer as we move far. Gona gore, when this potential difference is being lost, the bulbs are going to switch from far as we come closer to Resistor 1. Closer to the source power where we have energy. Akere?"*

Misconceptions in learner's minds during teaching sometimes depend upon the extent to which teachers hold the same misconception (Pardhan and Bano, 2011). Electric circuits is perceived to be a difficult topic to teach and one primary reason can be that everyday experiences can provide evidence that supports incorrect assumptions.

Table 1.13 : A summary of Mr. Dakalo's teacher knowledge

Content knowledge	Adequate amount of content but unorganised Subject Matter knowledge
Context knowledge	Adequate knowledge of the context
Student understanding	Inadequate knowledge of prior knowledge and misconceptions.

INSTRUCTIONAL STRATEGIES

EXPLANATORY FRAMEWORK

Magnusson et al (1999) says that a teacher can have the greatest content knowledge but if he does not have the best explanatory frameworks to teach the content it is a futile excuse. Mr Dakalo had a good analogy to explain resistance of the resistor. For example:

> *Teacher: "And then you are all in here. Ko thella molilo at the back or there's a snake somewhere there. What will happen? We are all going to run through the…."*
>
> ***Teacher:*** *"Komonyane?! And ha homonyane, what happens? The door doesn't allow us, neh?"*
>
> ***Learners:*** *"Yes."*

Teacher: *"Yes. It resists us. (Writing on the board) The door does what?"*

Learners: *(in chorus) "It resists us."*

Cutis and Rageluth, (1983) warned that verbal analogy alone is insufficient for learners to understand abstract concepts. It follows then that teachers should draw pictures and models of analogies. This was not the case with Mr Dakalo because he only explained the analogy verbally. Additionally, the teacher should have assessed the advantages and disadvantages of using the analogy in the introduction phase. Ideally, the analogy is best used to explain the relationship between current and resistance, especially in parallel connection. It is so because the resistors connected in parallel share the current according to the ratio of the resistor, that is the greater the resistance in parallel, the smaller the current it consumes.

ACTIVITIES

The teacher used physical science question papers from previous years as an activity. The papers had a question using a combination of series and parallel connections. This was difficult for the learners to answer because the teacher only taught them how to solve problem of series and parallel separately. The question also demanded that learners calculate the equivalent resistance. Learners were unable to answer it. This was evident when the teacher asked them to solve problems in the question paper and no learner responded. Furthermore, the teacher indicated before the observation that he prefers to give activities to the learner rather than to drill them with questions. For example,

> *Oh, let's do November 2015. Oh you don't have it, it's fine. Let me just draw the diagram because we need to explain while looking at it. Ah number 1 it's simple. But it's fine. Little things"*

However, the teacher only used previous examination question papers despite him indicating that he uses both the textbook and previous papers. The use of a few activities could have helped the teacher with information on learner's ability to apply critical thinking, analysis, synthesis, problem solving and creative thinking skills (Clarke, 2008). Additionally, for the learners it could have enabled them to retain the information for a longer period.

DIDACTICS

Mr Dakalo used lecture methods, and question and answer method. Lecture method is normally a one-way method unaccompanied by discussion, questioning or immediate practices that makes it a poor teaching method (Hatim, 2001). The teacher dominated the talk in the classroom while learners listened and take notes. This teaching method has been criticised for lack of effectiveness of an active learning approach (Berry, 2008). For example:

> *Teacher: "Ok, now if we are having identical resistors, the current that is going to go to Resistor 1 and Resistor 2 is going to be the same. Why? Because the resistors are identical. That is point number 1. Now, if the resistors are not identical, let's just assume we have 2 ohm here (labeling on the board) and then we have 5 ohm. I don't want the numbers that goes in terms of ratio of 2:4. The one that goes in terms of ratio 2:4 it's easy. I prefer 2:3, 2:5 and 7. Now another very important point, you must write it underneath parallel connection is this one, a s we agreed and made a conclusion to say, if a parallel connection, a parallel is divided according to the proportion of the resistors. Therefore, the biggest current will pass through the smaller resistor. And the smaller current will pass through a smaller resistor. I'm repeating myself, because we agreed that this current is going to be divided according to the proportion of the resistors, therefore the bigger current will pass through the smaller resistor. Akere? Bigger current pass through a smaller resistor, and then…"*

The lesson was teacher-centered in that the teacher focused on information rather than learners (AI-Rawi, 2013). The teacher also asked questions and expected learners to answer without explaining. These questions mostly required a yes or no answer. Although these questions helped the teacher to evaluate whether lesson objectives have been met and enhance independent learning (Maeda and Abe, 2010), It also limited their thinking skills. For example:

> *Teacher: "Ok, I think 2 classes from this block there's a hall, akere? That hall it's even bigger. Same people run. What will happen? We will all pass there. Akere?"*
>
> *Learners:"Yes."*
>
> *Teacher: "Ok. So that's how I introduce my lesson today. (Writing on the chalkboard) Electric Circuit. Whatever the analogy I just take you through, just*

put it in your mind. You will understand as we move on, neh?"

Learners: "Yes."

Therefore, the type of didactics used by the teacher deprives learners of developing problem solving and inquiry skills because learners only memorise information that could later be needed.

Table 1.14: A summary of Mr Dakalo` s Classroom instructional strategies

INSTRUCTIONAL STRATEGIES	Explanatory frameworks	Analogies (verbal) Illustration Models
	Activities	Class work (Previous question paper)
	Didactics	Lecture method and question and answer method

INTERACTION AND DISCOURSE

Interactions and discourse in the science classroom between the teacher and learners is important to learning because it is central to the meaning making process (Mortimer &Scott, 2003). This discourse refers to the language the learners and teachers use in the classroom to communicate (Foy, 2013). The teacher used authoritative discourse. It so because authoritative discourse is a discourse through which the teacher conveys information to the learners and his/her questions are instructional in nature. The teacher did not encourage debates and challenges. Mr Dakalo also did not foster student thinking and learning through negotiation process. For example:

Teacher: "It becomes dimmer and dimmer. Why does it become dimmer? It is because of the type of connection. Ok, that type of connection, let's give it a name. Now, type of connection. Very important part now of you understanding electric circuit that by the time I'm going to finish this explanation, everything will be done at last. (Writes on board) Series Connection. We said something becomes dimmer and dimmer. Now when we represent a Series Connection, this is what, this is our type of (sketches a circuit on board) connection, akere? Ehrr... These are my resistors. Oh, kana it is caps, Eish! (Makes correction on sketch). I forgot, I'm sorry. In CAPS, according to CAPS document, I must make rectangles, neh? Those are my *resistors. This is Resistor 1, this is Resistor 2 and that one is Resistor 3. Now because you have said that the light becomes dimmer and dimmer, we are going to make a conclusion that says, Vt, which is the potential difference at the house that is having the main power source, will be equals to the sum of those potential difference from the different houses. (Writes $Vt=V^1+V^2+V^3$ on board). Now but when I make this, we can make a conclusion to say, a potential difference across in series connection it is divided according to the proportion of the resistors. I start again. Because the bright becomes dimmer and dimmer as we move far away, we make a conclusion that says, according to this (Pointing at equation on board), the potential difference across a Series Connection, it is divided according to the proportion of the resistors. Meaning the Resistor 1 will have a greater potential difference than Resistor 2 and Resistor 3 because you have said, according to Tembisa's connection, the light becomes dimmer and dimmer as we move far. Gona gore, when this potential difference is being lost, the bulbs are going to switch from far as we come closer to Resistor 1. Closer to the source power where we have energy. Akere?"*

Learners: "Yes."

Authoritative discourse does not promote the specific aims of physical sciences that include communicating and evaluating conclusions as demanded by CAPS. The pattern of discourse used was initiation, response and feedback (IRF). In most cases Mr Dakalo asked questions to evaluate learners understanding. For example:

Learners: "Komonyane."

Teacher: "Komonyane?! And ha homonyane, what happens? The door doesn't allow us, neh?"

Learners: "Yes."

Teacher: "Yes. It resists us. (Writing on the board) The door does what?"

Learners: (in chorus) "It resists us."

This pattern of discourse (IRF) restricts learners' thinking, it also discourages learners from giving responses from their personal experience (Mortimer & Scott, 2003), since the teacher is the only initiator. The communicative approach used by Mr Dakalo was interactive but authoritative (Mudau, 2013). In interactive authoritative discourse the teacher invites learners' responses but discounts the wrong ideas (Chin, 2006). The teacher while teaching current in parallel connection had two resistors with 3 ohms and 4 ohms. The total current was 2,275A. The teacher indicated that the two resistors would divide the current according to the proportion of resistors. He then asked learners which one will receive more current. Learners have different views with some saying 3 ohms resistor and the others saying 4 ohms resistor. The teacher then said those who are saying 4 ohms resistor are wrong, without explaining why these learners are wrong.

Ideally, the teacher should have referred the learners to I=V/R, so that they are able to make their own conclusions by correcting their initial response on their own. Furthermore, this could have given learners an opportunity to develop prediction skills using the relationship of current and resistance in the formula.

Table 1.15: Summaries of Classroom interactions and discourse employed in the lesson

Classroom interactions and discourse	Type of discourse	Authoritative
	Pattern of discourse	IRF
	Teacher questioning	Evaluative
	Communicative approach	Interactive-authoritative

ACCOUNTABILITY

The teacher was accountable to the system. It is so because the teacher focused on completing the topic in the shortest period of time in which he used the previous question paper (November 2015) to drill learners on how to answer examinations questions. For example:

> *Teacher: "Oh, let's do November 2015. Oh you don't have it, it's fine. Let me just draw the diagram because we need to explain while looking at it".*

According to Jita (2004; 16) accountability to the system refers to the amount covered by the teacher to prepare his/her learners for the examination. Additionally, the electric circuits topic is allocated four hours in the CAPS document, Mr Dakalo finished the topic in an hour and started drilling learners with question papers. The teacher did not account to the subject. Mr Dakalo was also noticed rushing to finish the topic in the shortest period. The teacher used lecture method to give learners more information without pausing and ensuring that the meaning of concepts are made clear (Jita, 2004). The explanatory framework used by the teacher did not enable the learners to access the subject matter and make meaning. For example, the learners struggled to respond correctly to the question paper he gave as a class activity. This was evident when learners did not respond as they do corrections, leading to the teacher answering the questions on his own. This is against what he said during the interview that he teaches learners to understand so that they will respond correctly in the examination. For example:

> *Researcher: "When, you teach learners, do you teach them to understand or for examinations?"*
>
> *Mr Dakalo: "As I have said, I teach them to understand so that they will be able to approach any type of question and be able to master the subject and pass the examination. I don't teach for examination but to understand."*

Accountability to the learners focuses on inclusivity (Jita, 2004). Mr. Dakalo was not accountable to all the learners. A teacher who is accountable to learners make effort to assist all learners to understand the topic. Additionally, the teacher used real life situations and explained in the most spoken language to enhance their comprehension of the subject matter. For example:

> *Teacher: "And then you are all in here. Ko thella molilo at the back or there's a snake somewhere there. What will happen? We are all going to run through the…."*

This example did not cater for all learners because some of the learner do not know Alexandra and Thembisa. Furthermore, the teacher knew that he have progressed learners in his class; he did not give them grade 11 work, do revision and drill them with question paper as he indicated during the interview. For example,

> ***Researcher:*** *"Thank you very much. Do you have progress learners in your class who failed Physical Science in Grade 12 and if 'yes' how do you ensure that you close the content gap?"*
>
> ***Mr Dakalo:*** *"Yes Mnr, eish. Because you know that kids you know kids they are slow but I try to give them Grade 11 work on the afternoons so that*

I can close the gap. Do revision with them, drill them over the questions."

Researcher: *"Oh so you are using the afternoon lessons to assist the Grade 11s content. What type of questions do you use to grill the afternoon lessons?"*

***Mr Dakalo**: "I structure my questions. I first start with level 1 questions take Grade 11 work. Level 1 question couple that with Grade 12 work. Then when they understand Level 1 question now I move to Level 2. After that, I couple that. I don't teach them Level 4."*

The teacher also did not differentiate the questions when giving an activity to accommodate progressed learners as he indicated during the interviews Therefore, the accountability of Mr. Dakalo was with the system.

Table 1.16: Summaries of Teachers accountability

Accountability	System	Mr Dakalo: "Oh, let's do November 2015. Oh you don't have it, it's fine. Let meme just draw the diagram because we need to explain while looking at it".
	Subject	Mr Dakalo: "As I have said, I teach them to understand so that they will be able to approach any type of question and be able to master the subject and pass the examination. I don't teach for examination but to understand."
	Students	Mr Dakalo: "Oh so you are using the afternoon lessons to assist the Grade 11s content. What type of questions do you use to grill the afternoon lessons?"

4.4 CASE 3: MR. TEBOGO

4.4.1. Data presentation

The data is presented as follows.

The following table gives the key words:

KEY WORDS		
Words	**Symbol**	**Explanation**
Prior Knowledge	PK	Knowledge required to learn electric circuits

Sequencing Ideas	SI	Sequencing of ideas to teach electric circuits
Content Knowledge	CK	The information the teacher teaches and expects learners to understand
Subject Matter Knowledge	SMK	Knowledge the teacher uses to assist learners to learn content in a meaningful way
Incorrect Subject Matter Knowledge	ISMK	Inappropriate knowledge of the teachers to assist learners to learn the content

A. Teacher knowledge

The Table 1.17 below presents Mr. Tebogo's knowledge and such knowledge comprising of the following categories, namely content, context and teacher's learners' understanding. The three categories consist of several characteristics as shown in the table below.

Table 1.17: Teacher knowledge (Mr. Tebogo)

Theme	Category	Characteristics
Teacher knowledge	Content knowledge	**Mr. Tebogo:** "I usually tell my learners that, in a series connection, it's when the resistors are connected one after the other. And there's only one path for the current to flow. There's no alternative part. Which means there's no branching of the current. But once there's a branching, it becomes the parallel connection of the resistors." **Interviewer:** "So if you were to explain in terms of parallel connection you would say that, a parallel connection there is an alternative branch for the current to flow. Whereas, in series there is only one path for the current to flow?" (organised subject matter) **Interviewer:** "Thank you very much Mr. Tebogo. What would you say to a learner who says when the switch is closed, the 4 ohm resistor will receive the same current as the 5 ohm resistor?" **Mr. Tebogo:** "I would have said to the learner, the learner is quite correct. Because those ones they are connected in series. So the resistors in a connected

		series they are known as the potential difference dividers but the current stays the same."(correct subject matter) Teacher: "Current is divided, akere? Ok under parallel connection, the potential difference is the same. And current is divided kedi current dividers and then potential difference is the same. Meaning, $V_{ţ}=V^1=V^2=V^3$ depending on circuit yarona itlabe ile potential difference ebokae. Akere? Then current he bare current dividers bare $I_{ţ}=I^1+I^2+I^3$ akere? Ko depender gore gonale amp meter tse kae mo circuit ya rona akere? Then resistance is $R_{ţ}=R^1+R^2+R^3$ akere? Ke parallel akere?" **(incorrect order deficiency subject matter)**
	Context	**Interviewer:**"Oh alright. No, thank you very much. Ehrr.. How long is your period and how many are you going to have today?" **Mr. Tebogo:** "Usually it's a 30 minute period but today I'm going to have twice of those." **Interviewer:**"Oh so it will make it an hour today?" **Mr. Tebogo:"**Yes. It's going to make it to be an hour, yes." Interviewer: "Ok thank you very much Mr. Tebogo. Ehrr… Which language or languages do your students speak?" **Mr. Tebogo:** "My student, mostly they speak isiZulu and the others the speak seTswana."
	Student understanding	**Mr. Tebogo:** "The prior learning you must bring to class when they start to provoke or when the electrical circuits are starting to be treated. They must bring the behavior of the resistances that are connected in series and those that are connecting in parallel. Their properties, their behavior. Then if they first master those, then is becomes much

		easier for them to comprehend the topic."(prior-knowledge) **Mr. Tebogo:** "At one stage I saw my learners, there was a combination of a series connection and the parallel connection. So my learner failed to combine the 2 that are in the series. Then he treated the one that is in series with the one that is in parallel as if they are in parallel. He was not aware of that, that is the combination of the 2 connections type of resistors."

B. INSTRUCTIONAL STRATEGIES

Table 1.18 below presents Mr. Tebogo's instructional strategies comprised of the following categories, namely Teaching methods, Explanatory Framework and activities. The three categories consist of several characteristics as shown in the table below.

Table 1.18: Instructional strategies (Mr. Tebogo)

Instructional strategies	Explanatory frameworks	Illustration (verbal)
	Activities	**Teacher:** "Current and resistance are inversely proportional, akere? And then le bona from Ohm's Law. So, kelefile question paper yaNovember 2015. Let's go to question number 11. The circle below is used to determine the resistance of resistor X. La e bona?" **Learners:** "Yes Sir."
	Didactics	Teacher: "Ok, ari R=0 because the switch is open so there is no current passing through. And omongwe o kreyile 16. Anyone with a different answer from these 2? (in SeTswana) Ok, when switch is open, ha hona current that passes through. You are correct. When switch is open, there's no current that passes

		through. Akere? A hona the flow of current. But heso, ari the 12V battery has internal resistance. When switch S is closed, the reading on the Amp meter is 0,5, akere? From the diagram the switch S is open but the reading says when switch S is closed the reading on the Amp meter is 0,5 Amperes. So there's a flow of current. While or resistance is not 0. And then ha re tshekile circuit eyo, the resistors are connected in series, akere? And the under series laitsi gore current is the same. O rang both resistor in ohms and X o shera the same amount ya eng, ya current. And then the total potential difference which is 12V. Then ra user Ohm's Law to calculate the unknown resistance, which is resistance X. Number 1, determine the total resistance using total potential difference and total current. Then you found the total resistance, akere? Since our circuit is connected in series, we Rţ=R^1+R^2. We know or Rţ which is 24 and then R^1 is 8 Ohms. So our R^2 is equal to 16 Ohms. La e bona?" (lecture method)

C. CLASSROOM INTERACTIONS AND DISCOURSE

Table 1.19 below presents classroom interactions and discourse comprised of the following categories, namely types of discourse, patterns of discourse and teacher questioning. The three categories consist of several characteristics as shown in the table below.

Table 1.19: Classroom interactions and discourse (Mr. Tebogo)

Interactions and discourse	Types and pattern of discourse	Teacher: "Current and resistance are inversely proportional, akere? And then le bona from Ohm's Law. So, kelefile question paper yaNovember 2015. Let's go to question number 11. The circle below is used to determine the resistance of resistor X. La e bona?" Learners: "Yes Sir."

		Teacher: “Ok. O eletsa tsona? Ye?” Learners: “Yes Sir.”
	Teacher questioning	Teacher: “Oh Series. Let’s go to parallel. 1 over, 1 over, 1 over (writing on board). Ok, rea koSeries akere? Series, current is the same. Meaning I total (Iţ) is equals to I one (I^1) is equals to I two (I^2) is equals to I three (I^3). Akere? Then V potential minus. Meaning V total (Vţ) is equals to V one (V^1) plus V two (V^2) plus V three (V^3). Akere? Therefore total resistance ya teng R total (Rţ) is equals to R one (R^1) plus R two (R^2) plus R three (R^3). La e bona?” Learners: “Yes.”
	Communicative approach	Teacher: “And then, what is the reading across the 4 Ohm resistor?” Learner: “12 volts.” Teacher: “No, anyone to try?”

D. Accountability

Table 1.20: Accountability (Mr. Tebogo) the table below presents teachers accountability comprised of the following categories, namely types of accountability. The three categories consist of several characteristics as shown in the table below.

Table 1.20: Accountability (Mr. Tebogo)

Accountability	System	**Interviewer:** “Thanks, thanks a lot Mnr. When you teach your learners, do you teach them to understand or do you teach them for examinations? Any answer you choose or take please explain it a bit further.” Mr. Tebogo: “For me because now our teaching is much on examination orientated, I teach them to pass the examination. Just because if I can teach them to understand I won’t able to finish on time. So I teach them to able to answer an examination question paper. Then is end there.”

		Teacher: “Current and resistance are inversely proportional, akere? And then le bona from Ohm's Law. So, kelefile question paper yaNovember 2015. Let's go to question number 11. The circle below is used to determine the resistance of resistor X. La e bona?” **Interviewer:** “So, generally, you are saying 4 hours is not enough to teach th e whole electric circuit topic.” **Mr. Tebogo:** “Yes. Is not enough unless is a hit and run. But at the end of the day is come back and harmed you.”
	Subject	**Interviewer:** “So in order, because you are now chasing time, what alternative means do you come up with in order to ensure that the content is covered?” **Mr. Tebogo:** “I go for an extra mile conducting extra classes. Morning classes, afternoon classes and even weekend classes because I want to have assurance that the learners have able and have understood what I have been teaching to them.”
	Student	**Interviewer:** “Thank you very much. This question I think it's irrelevant but it's only fair that we answer it. Do you progress learners in your class who fail Physical Science in Grade 11? If ‘yes’ how do you ensure that they close the content gap or the prior knowledge?” **Mr. Tebogo:** “Yes I do have those kind of learners who have progressed from Grade 11 who have failed Physical Sciences. But, as now we are preparing for the examination, I have started a initiative to say now I must divide them and they must not feel offensed but is for their own good. Those that are doing well, I give them extra work to continue with work. But those that are struggling, I sit down with them and I help them where I can. I think

		that one is going to help them to improve their performance in the oncoming examination."

4.4.2 Discussion and findings

Mr. Tebogo began his lesson by asking learners to state ohm's law. A learner stated the law as "Ohm's Law States that the amount of electric current through a metal conductor at a constant temperature in a circuit is proportional to the voltage across the conductor". The teacher then reiterated the statement. He then wrote the formula R=V/I and explained that R represents resistance and it is measured in ohm's, while V is potential difference measured in volts and I is current measured in amperes. The teacher then brought the types of connection in electric circuits. He asked the learners to give characteristics of a parallel connection. A learner indicated that in parallel, the voltage is the same and the current is divided. The teacher then wrote Vt=V1+V2+V3 and It = I1+I2+I2. He also wrote Rt=R1+R2+R3. The learners then corrected him and said the formula he wrote is for series connection. He then quickly erase and write 1/R=1/R1+1/R2+1/R3. He then asked the relationship between potential difference and resistance. The learners said that "voltage and resistance are directly proportional". The teacher then asked the learners to answer the paper he distributed to them. Ideally, after the learner stated ohm's law, the teacher should have corrected the learner and state ohm's law as stated in the CAPS document, Thus, "The potential difference across the a conductor is directly proportional to the current in the conductor at a constant temperature". Secondly, when explaining parallel and series connections, the teacher should have drawn the model of parallel circuits with three resistors connected to both a voltmeter and ammeter. This could have assisted learners to see how parallel circuits look like. Thus, the teacher taught the subject matter knowledge as if the learners already knew it. According to Mudau (2015), organisation of subject matter refers to the sequencing of concepts. Therefore, Mr. Tebogo's content knowledge was poor.

The teacher demonstrated adequate context knowledge. Mr. Tebogo was aware of the language spoken by learners outside the school and the number of learners in his class. For example:

> ***Interviewer**: "Ok thank you very much Mr. Tebogo. Ehrr… Which language or languages do your students speak?"*
>
> ***Mr. Tebogo**: "My student, mostly they speak isiZulu and the others the speak seTswana."*

__Mr. Tebogo__: "Oh! The number of learners. In my class they are 34 learners."

Additionally, he was aware of the resources available in class that helped him to teach the topic better. The teacher was noted displaying the electric circuit's formulae using the smart board. According to Mudau (2013), knowledge of context refers to the contextual aspects that could influence teaching.

Mr. Tebogo's knowledge of student understanding was inadequate. This was noticed when he introduced his first lesson in that he did not check what learners already knew about the topic. Here, he immediately discussed the characteristics of electric circuits. Ideally, he could have asked that the learners what they know about electric circuits. This would have assisted him to determine how much learners knew about the topic and to identify any misconceptions. It is important because learners' learning capabilities depend largely on their prior knowledge and experiences. Furthermore, constructivists argue that learner's ideas should be a point of departure in teaching (Hammer, 1996).

Table 1.21: A summary of Mr. Tebogo's teacher knowledge

Content knowledge	Disorganised subject matter Adequate subject matter knowledge
Context knowledge	Adequate knowledge of knowledge of the context
Student understanding	Poor knowledge of prior-knowledge and misconceptions

INSTRUCTIONAL STRATEGIES

Explanatory frameworks

According to Shuman (1987, p15), ''content and pedagogy are blended, in that the teacher should combine his or her understanding about a topic with instructional strategies and additional knowledge to promote student learning''. Magnussion et al (1999) also indicates that a teacher can have the best content knowledge but if he does not have the best explanatory frameworks to teach the content it is a futile exercise. Mr. Tebogo did not use analogies and models to help learners access the topic of electric circuits. Explanatory frameworks are important in science, especially when teaching abstract concept like electric circuits (Cutis & Reigeluth, 1983). Furthermore, models and analogies could have eliminated some of the misconceptions learners may hold (Duit, 1991). For example, while explaining series and parallel connections, Mr. Tebogo did not model the circuits. Duit (1991) indicates that various models are used to build comprehensive bridges between reality and models. Additionally, he did not explain or use analogies to assist learners in understanding how current splits in parallel connections. Analogies have been found to be helpful to learners with weak comprehension skills to understand abstract concepts (Duit, 1991).

Didactic perspectives

Mr. Tebogo's lesson was dominated by lecture, and question and answer method as didactics. According to Mudau (2013), didactics include traditional teaching methods like lectures and demonstration methods, which the teacher uses during lesson presentation. For example, while explaining series and parallel connections, the teacher delivered large amounts of information to the students in a short period (Berry, 2008). There was little or no time for learners to make inputs. For example:

> *Teacher: "Current is divided, akere? Ok under parallel connection, the potential difference is the same. And current is divided kedi current dividers and then potential difference is the same. Meaning, $V_ţ=V^1=V^2=V^3$ depending on circuit yarona itlabe ile potential difference ebokae. Akere? Then current he bare current dividers bare $I_ţ=I^1+I^2+I^3$ akere? Ko depender gore gonale amp meter tse kae mo circuit ya rona akere? Then resistance is $R_ţ=R^1+R^2+R^3$ akere? Ke parallel akere?"*

This method of teaching can help learners learn best through the modelling of examples by the teacher (Moore & Hansen, 2012). However, Mr. Tebogo did not use examples in his teaching and that lead to other learners getting bored in the classroom (Nieman & Monyai, 2011). This was evident during the lesson because only three learners were active. Furthermore, the method does not promote social interaction between the teacher and learners which is crucial in learning (Nguyen, Williams, and Nguyen, 2012). It was also noticed that there were no questions asked by learners since the teacher was only concerned about finishing the concepts, thus it discouraged learners to inquire and thick critically.

ACTIVITIES

Class activities were used as an activity to help learners comprehend the content. Mudau (2013) points out that activities include problems, demonstrations, simulations, investigations or experiments which the teacher uses to help learners comprehend the content. Although there was a smart board in good working condition, the teacher did not it use optimally in that he should have used it to demonstrate the electric circuit in the form of experiments to improvise for the lack of equipment in the laboratory. According to Hofstein and Lunetta (2004), teaching strategies incorporating experiments are considered to be the most important educational tools in the classroom, especially for teaching abstract concepts. Moreover, the teacher should have given an activity about parallel connections immediately after teaching this type of connect. This could have helped him to monitor progress and correct misconceptions at once.

Table 1.22: A summary of Mr. Tebogo` s Classroom instructional strategies

Instructional strategies	Explanatory framework	Illustration
	Activities	Class work
		Displayed formulas via Smart board
	Didactics	Lecture
		Question and answer

INTERACTION AND DISCOURSE

For many learners the greatest barrier to learning science is the language barrier (Osborne, 1996). According to Moore (2007), language and discourse are co-dependent. It follows then that language is used to make classroom discourse (Foy, 2013). Mr. Tebogo's classroom discourse was authoritative in that he dominated the lesson by conveying information and his questions were instructional in nature (Chin, 2006). In an authoritative discourse, the statements are factual and do not encourage the purpose of physical sciences, which is to equip learners with communication skills (CAPS, 2011). Mr. Tebogo's lesson was authoritative because learners only responded to his questions. For example:

> **Teacher:** "So let's take the relationship between potential difference and resistance. What is the relationship between potential difference and resistance? The difference between potential difference or voltage and resistance. Mojapelo."
>
> **Learner:** "Voltage and resistance are directly proportional."
>
> **Teacher:** "Voltage and resistance are directly proportional, akere? And the relationship between current and resistance? Maphangu."
>
> **Learner:** "Current and resistance are inversely proportional."

Unlike authoritative, dialogic discourse encourages debate and challenges (Chin, 2006). Mr. Tebogo did not make use of dialogic discourse because there was no stage during the lesson where the teacher allowed learners to discuss and draw conclusions on their own. Furthermore, he did not sequence his lesson in such a way that it allowed learners to relate the concept to their real life experience.

The pattern of discourse was initiation, response and feedback. During the lesson, Mr. Tebogo was initiating the interaction by asking a question that needed yes or no; these questions were evaluative in nature. The learners would respond and the teacher will give a feedback by agreeing or disagreeing with the learners. For example:

> **Teacher:** “Current and resistance are inversely proportional, akere? And then le bona from Ohm's Law. So, kelefile question paper yaNovember 2015. Let's go to question number 11. The circle below is used to determine the resistance of resistor X. La e bona?”
>
> **Learners**: “Yes Sir.”
>
> **Teacher: “**Ok. O eletsa tsona? Ye?”
>
> **Learners:** “Yes Sir.”

This pattern of this discourse has the advantage of challenging the teacher to find a better way of explaining (Stanger-Hall, 2012). It is so because the teacher can check if learner understands or not and can correct misconceptions at the same time. However, it may not allow learners enough time to think (Mortimer and Scott, 2003). Mr. Tebogo did not employ initiation, response, feedback and feedback pattern of discourse. He did not use his feedback or provoke learners to elaborate upon their responses from the learners’ point of view.

The communicative approach in Mr. Tebogo’s classroom was interactive but authoritative (Chin, 2006). In an interactive-authoritative approach, the teacher focuses on specific points of view and leads learners through a question and answer routine with the aim of establishing and consolidating that point (Mortimer & Scott, 2003). The teacher asked learners questions with pre-determined answers. Thus, he wanted learners to respond in a particular way. For example:

> **Teacher:** “Volts akere? And then current? SI unit for current?”
>
> **Learners:** “Amperes.”
>
> **Teacher:** “Amperes, akere? So there are 2 types of circuits. We have a Parallel Connection and then a Series Connection. Under Parallel, go eragallang in terms of potential difference and current? From Grade 10 under parallel.”

Learner: “Under parallel, voltage is the same.”

Teacher: “Voltage is the same.”

Learner: “Throughout the circuit.”

Teacher: “Throughout the circuit. And then? What about current?”

Learner: “Current is divided.”

The teachers practice did not promote knowledge and skills in scientific inquiry and problem solving because the teacher was the only source of information, and what he said was considered to be final even though learners’ responses were invited. For example:

Teacher: “And then, what is the reading across the 4 Ohm resistor?”

Learner: “12 volts.”

Teacher: “No, anyone to try?”

The teacher should have allowed the learner to explain his response. This could have assisted the learner to correct his/her mistake. It could have improved the learner’s confidence. According to Scott (1998), physical science teachers can also use teacher-learner talk around the concept to facilitate learning. Mr. Tebogo only focused on the activity in that he gave learners a previous question paper to help influence learning. However, learners were not given time to talk about the concept. Ideally, after teaching that the resistors connected in parallel split the current while the voltage remains constant, he should have allowed the learners to discuss why it is so. This could have stimulated learners’ reasoning skills as well as improving their communication skills.

Table 1.23: Summaries of Classroom interactions and discourse employed in the lesson

Classroom interactions and discourse	**Types of discourse**	Authoritative discourse
	Patterns of discourse	Initiation-teacher
		Response-learner
		Feedback-teacher
	Teacher questioning	Evaluate the lesson
	Communicative approach	Interactive-authoritative

Accountability

Accountability to the system

During the interviews, the teacher indicated that:

> **Mr. Tebogo:** “For me because now our teaching is much on examination orientated, I teach them to pass the examination. Just because if I can teach them to understand I won’t able to finish on time. So I teach them to able to answer an examination question paper. Then is end there.”

This statement indicates that Mr. Tebogo’s accountability was to the system. According to Jita (2004), teachers who are accountable to the system teach in such a way that they finish the curriculum in the shortest period of time. Here, the attention is more on information delivered than learner understanding. Mr. Tebogo rushed to cover the topic and started drilling learners with previous question papers. For example:

> *Teacher: “Current and resistance are inversely proportional, akere? And then le bona from Ohm's Law. So, kelefile question paper yaNovember 2015. Let's go to question number 11. The circle below is used to determine the resistance of resistor X. La e bona?”*

Accountability to the subject

The teacher was not accountable to the subject. This was evident when he was presenting the lesson to the learners. Mr. Tebogo did not make means to ensure that learners comprehended concepts such as resistance and current. Here the teacher should have used research explanatory frameworks such as the water-pipe analogy. Additionally, the teacher did not teach ohmic and non-ohmic conductors despite the fact that the CAPS prescribed them to be taught in grade 11 and 12. The CAPS also demands that learners should be able to define/state ohms law in words, equation and graphically. The teacher only stated the law in words. Teachers who are accountable to the subject make use of explanatory frameworks to enable learners to access subject matter (Mudau, 2013). During the lesson, Mr. Tebogo did not use analogies, modes and examples to help learners make meaning to the concepts.

Accountability to the learners

Even though Mr. Tebogo knew the contextual factors such as progressed learners and shortage of resources in his class, he did not improvise with what he has to assist the learners. For example, Mr. Tebogo had a smart board, which was operational. He could have demonstrated a video on how current flows, how resistors resist current and how internal resistance works. This could have helped learners in that some learners learn best by seeing. Accountability that focuses on all learners regardless of their gender, race, language, any form of disabilities etc is called accountability to the learners (Jita, 2004). Secondly, the teacher knew that he had ten progressed learners in his class who had failed grade 11 physical sciences. It follows then that these learners have content knowledge gaps and therefore should be specially catered to during teaching. Mr. Tebogo did not assess learners' prior knowledge nor did he teach grade 11 science concepts in relation to electric circuits. Therefore, Mr. Tebogo's accountability was not to the learners.

Table 1.24: Summaries of Teachers' accountability

Accountability	System	• "For me because now our teaching is much on examination orientated, I teach them to pass the examination. Just because if I can teach them to understand I won't able to finish on time. So I teach them to able to answer an examination question paper. Then is end there."
	Subject	• Mr. Tebogo's accountability was not with the subject
	Students	• Mr. Tebogo did not account to the learners.

4.5. CONCLUSION

This chapter presented, discussed and made findings from the data of the three cases identified to answer the research questions. Interviews and observations of teachers teaching the topic were saught as procedures for data collection, which was analysed using the typology approach. Furthermore, the CPDF frames were used to code, organise, account for and explain the data for each case. The three participants were given the pseudonyms Mr Phakama, Mr Dakalo and Mr. Tebogo. Moreover, it is only the components that were presented that helped in answering the research question. The next chapter presents answers to the research questions and recommendations of the study

CHAPTER 5:
SUMMARY OF FINDINGS AND RECOMMENDATIONS

5.1. INTRODUCTIONS

This chapter presents the summary of findings. It also answers the research questions and presents the contributions and shortcomings of the study.

5.2. RESEARCH QUESTIONS

This study was undertaken to explore the nature of teachers' classroom practices in the topic electric circuits, physical sciences. The focus was on teacher knowledge, instructional strategies, and interactions and discourse as well as accountability.

The study was guided by the following research question:

What is the nature of teachers' classroom practices when teaching electric circuits in a grade 12 classroom?

The question led to the following sub-questions:

- What is the nature of the teachers' teacher knowledge when teaching electric circuits?
- How do the instructional strategies used by the teacher shape classroom interactions and discourse?
- How does accountability shape teachers' instructional strategies, interactions and discourse?

5.2.1 What is the nature of the teacher teacher's knowledge when teaching electric circuits?

A. Case 1 (Mr Phakama)

The study found that Mr Phakama's content knowledge was adequate. This was noticed when he was found teaching relevant content as prescribed by the curriculum. Additionally, Mr Phakama had a strong command of subject matter knowledge, which was also organised. Mr Phakama demonstrated adequate context knowledge. For example, he was aware of the condition of the laboratory, he used his knowledge to improvise and he used a smart board. The teacher also demonstrated adequate knowledge of student understanding. For instance, he was aware of the prior knowledge learners needed to have in order to learn electric circuits in grade 12 easily. Therefore, Mr Phakama's teacher knowledge of electric circuits was adequate.

B: CASE 2 (Mr Dakalo)

The study revealed that Mr Dakalo's amount of content knowledge was adequate but not organised. The teacher knew what the curriculum expected learners to learn but his sequencing of concepts was poor. Mr Dakalo demonstrated adequate knowledge of the context. For example, he was aware about time allocated to teach in a day and the contextual factors facing his learners that could hamper teaching and learning.

Mr Dakalo was aware of the prior knowledge learners must bring in to the class, however he did not start his teaching from the learners' point of view. He also shared some misconceptions with the learners. For instance, he had a misconception that the light bulbs become dimmer further from the positions at which they are connected. Therefore, Mr Dakalo teacher's knowledge was poor.

C: CASE 3 (Mr. Tebogo)

The study has revealed that Mr. Tebogo's content knowledge was not organised, however, there was sufficient SMK. For instance, at some point he used a formula to calculate resistance in parallel for series connections. Furthermore, the CAPS demands that teachers must teach ohmic and ohmic conductor but Mr. Tebogo did not teach them. The teacher had adequate knowledge of context. The teacher was using both the smart board and the white board to influence teaching and learning. However, the teacher had poor knowledge of student understanding. Mr. Tebogo did not check learners' prior knowledge and misconceptions at the beginning of the lesson. Therefore, Mr. Tebogo's teacher knowledge was poor.

5.2.2 How does the instructional strategies used by the teacher shape classroom interactions and discourse?

A. CASE 1 (Mr Phakama)

The study revealed that Mr Phakama's relevant instructional strategies invited learners to contribute to learning. His integration of lecture methods, demonstrations, illustrations, and video clips promoted learner understanding. Moreover, the use of analogies led to type of interactions and pattern of discourse that influenced learning. Allowing learners to raise questions and explaining their answers more helped learners with reasoning and inquiry skills.

B: CASE 2 (Mr Dakalo)

The study revealed that Mr Dakalo''s instructional strategies were one way, in that he was the only one who was active during teaching and learning. This is so because learners were taking notes and no opportunity was given to interact with the teacher. This lead to interactions and discourse that do not acknowledge alternative concepts. His approach to learning was generally a lecture method accompanied by patterns of discourse that restricted learner thinking. Thus, the instructional strategy was lecture method with IRF, and interactive but authoritative discourse.

C: CASE 3 (Mr. Tebogo)

The study revealed that Mr. Tebogo used lecture methods in his lesson presentation. It is so because he dominated the lesson by giving information to the learners. His interactions and discourse only allowed him to ask questions. Learners were expected to give a response to the teacher's questions. Therefore, the instructional strategies used were lecture methods, which lead to IRF, and interactive but authoritative discourse.

5.2.3 How does accountability shape teachers' Instructional strategies, and interactions and discourse?

A. Case 1 (Mr Phakama)

The study revealed that Mr Phakama's accountability was to the subject in that he focused on how learners understand concepts. The teacher also indicated during the interviews that he teaches learners to understand so that they are able to answer examination question papers correctly. His accountability led to him using analogies, models, examples as his explanatory frameworks. Additionally, the teacher used class work, homework's and played a video of an experiment as his activities. The teacher relied on a combination of didactic methods in that he used lecture methods, question, answer, and demonstrations during the lesson.

The study also revealed that the class was interactive in nature as he involved learners during the lessons, thus, the communicative approach employed by Mr Phakama was interactive-authoritative. The pattern of discourse was IRFRF in that the teacher allowed learners to explain their answers in details. Lastly, during the lesson it was observed that Mr phakama asked questions to evaluate learners understanding and also to develop the lesson.

B. CASE 2 (Mr Dakalo)

The study revealed that Mr Dakalo's accountability was to the system in the he rushed to finish the curriculum. Although in the interviews he indicated that, he teaches learners to understand so that they are able to respond, his practices proved otherwise. Furthermore, his explanatory frameworks were limited to analogies, illustrations and models. There were not enough activities that supported teaching and learning in that the teacher only gave one piece of class work. This class work was in the form of a previous question paper.

The teacher dominated his class by using lecture methods and where question and answer methods were used, it was limited and evaluative in nature. He even indicated during the interview that he asks questions to evaluate.

The study also revealed that Mr Dakalo's class was interactive but authoritative in that he dominated in the classroom. The study also revealed that Mr Dakalo used the IRF pattern of discourse.

C. CASE 3 (Mr. Tebogo)

The study showed that Mr. Tebogo is accountable to the system in that his explanatory frameworks did not enable his learners to access the subject matter. Further to that is that he rushed to finish the topic in the shortest period possible using lecture method. The teacher focused on preparing his learners for examinations in that he taught the topic in twenty minutes instead of four hours and started drilling the learners with previous question papers. Mr. Tebogo also indicated that given the pressure from the district, teaching has become more about examination than understanding.

The study also revealed that Mr. Tebogo's questioning was evaluative. The nature of communicative approach was interactive but authoritative. Although the teacher invited learners' responses through question and answer, he was the dominant voice in the classroom. Lastly, the teacher employed IRF pattern of discourse.

Here below I present the answer to the main research question per case.

5.2.3 What is the nature of teachers' classroom practices when teaching electric circuits in grade a 12 classroom?

A. CASE 1 (Mr Phakama)

The study found that Mr Phakama's teacher knowledge was adequate to teach electric circuits in grade 12. It was observed that his amount of subject matter knowledge was organised. For instance, the teacher was found to be teaching content as prescribed by the Curriculum and Assessment Policy Statement (CAPS). Additionally, he organised the content to move from simple to complex in that he started the lesson from the learners' point of view. He did so by assessing learners' prior knowledge and this assisted him to correct some of the misconceptions learners had. For example, some learners had a misconception that a battery and a cell were the same component. The teacher corrected that by indicating that a battery is a combination of two or more cells whereas a cell is only one. It is important that teachers are aware of learners' misconceptions in order to design appropriate instruction (Morrison and Lederman, 2003).

The study revealed that the teacher integrated his didactics methods of teaching in that he did not rely on one method. For example, lecture method. The teacher used different explanatory frameworks such as analogies, models and illustrations. McNicholl (2007) indicates that a teachers' use of explanatory frameworks is a very important aspect of the teachers' pedagogical content knowledge. For instance, the teacher used the water pipe analogy to explain how current in parallel connection is divided. This water circuit analogy has proved helpful to teaching electric circuits, particularly the behaviour of current in parallel connection (Pfister, 2004).

The activities included a video demonstration of internal resistance in the form of an experiment. The teacher did this to improvise for the lack of apparatus in the laboratory by using a smart board. The use of video demonstration helped learners to enhance knowledge acquisition to a greater extent.

The study also found that Mr Phakama created a classroom environment where everyone's contribution is valued. The teacher did not discount wrong answers from learners but rather encouraged them to support their answers. This led to IRFRF pattern of discourse accompanied by interactive but authoritative communicative approach.

The accountability to the subject was the main objective behind the lesson. The evidence shows that the teacher was more concerned about learners' understanding than finishing the curriculum in the shortest period. For instance, the teacher spent an hour of the four hours allocated to teach the whole topic teaching only grade 10 and 11 content. Thus, accountability to the subject shapes the teacher to teach for understanding rather than examinations.

B. CASE 2 (MR DAKALO)

The study has revealed that Mr. Dakalo's class was characterised by sufficient SMK but unorganised. For instance, the teacher was found teaching resistance and series connections at the same time. Further to that, he would talk about resistance and suddenly talk about what is expected from learners.

The teacher knowledge of learners' understanding was inadequate. Thus, he did not start his lesson from the learners' point of view by assessing their misconceptions. Furthermore, the teacher shared a misconception that learners had; for example, the teacher believed that connected light bulbs become dimmer and dimmer because of the position they are connected in. This is in incorrect because the type of circuit is the factor determining the brightness of the light bulbs. Further to that is this in not in the CAPS curriculum.

This is the misconception learners had. This was found when he asks learners to explain what happens to the light bulb connected far from the battery; learners indicated that the light bulbs become dimmer as they move away.

The teacher depended upon lecture method to present his lesson. This is against the recommendation of CAPS (2011), which indicates that for a subject to be regarded as science a certain method of inquiry must be used. In inquiry, learners explore content by asking questions, investigating and then answering questions (Kuhn, 2007). The lecture method denies learners the opportunity to know what they know, how they know what they know and why they believe what they believe they know (Chin, 2007).

The nature of communicative approach was interactive but authoritative in that the teacher invited learners' responses, however no opportunity was offered to the learners to ask questions, thus leading the classroom pattern of discourse to be IRF. The learner's role was to respond to the questions asked by the teacher.

The study found that the teacher was accountable to the system. This is also because the teacher was seen rushing to finish the topic in an hour. The teacher indicated that the topic is difficult for learners to understand because of the way teachers teach the topic. However, it was observed that he also wanted to finish the topic in the shortest period so that he drills the learners with question papers. Thus, accountability to the system is not desirable in science because it shapes teaching that focuses on finishing the curriculum rather than understanding.

C. CASE (MR. TEBOGO)

The study found that Mr. Tebogo's SMK was insufficient. He was found using the wrong formula to calculate the total resistance on a parallel connection. For instance, he indicated that to calculate the total resistance in parallel learners should use Rt = R1+R2+R3. Furthermore, the teacher's SMK was not organised in the way he was found teaching series and parallel connections as if learners already knew the difference. For example, the teacher did not draw the model of the circuits to learners to identify the circuits. The teacher also did not access learners' prior knowledge at the beginning of the lesson. This could have assisted him to correct misconceptions learners have about electric circuits. This is also because constructivists argue that learners' ideas should be a point of departure in teaching (Hammer, 1996).

The study also revealed that the teachers' lesson was teacher-centred. The teacher dominated the lesson by giving learners more information, which was of factual statements. Teacher-centred is closely linked to lecture methods in that the teacher is the only source of information. Lecture method in a science classroom does not bring good results in science education. Thus, an inquiry approach is desired.

Evaluative teacher questioning characterised Mr. Tebogo's class. For instance, when teaching series connections, the teacher asked learners what happens in terms of potential difference and current. Learners responded that the voltage is the same and the teacher encored their response and again indicated that the current is the same. There was no attempt by the teacher to use learner's responses to develop the lesson. Mr. Tebogo's communicative approach was interactive but authoritative in that the interaction was one-dimensional.

Accountability to the system was the main reason behind which the teacher presented his lesson. The teacher was found to be covering the curriculum in the shortest period of time possible. The teacher did so by using lecture method. He then drilled the previous question paper for the rest of the lesson. Here, no activities or examples were used to help learners understand. The teacher seemed to be concerned on how well his learners could answer the previous question paper. Thus, accountability to the system shapes the teacher to use lecture methods.

The use of CPDF was of paramount importance in this study. It is so because it entails frames that the researcher intended to scrutinise. These frames include teacher knowledge, instructional strategies, interactions and discourse and accountability. The framework teacher knowledge frame, whichs entail content knowledge, context knowledge and knowledge of student understanding, informs the instructional strategies that the teacher uses. The instructional strategies shapes the interaction and discourse. Additionally, accountability to which the teacher is accountable to influences instructional strategies and results.

5.3 MAIN CONTRIBUTIONS TO THE STUDY

Previous studies in the electric circuits topic have mainly been about identifying learners misconceptions. In this study, the focus was on physical science teacher's classroom practices. The study on the nature of classroom practices was important given the performance of learners in physical sciences in grade 12, particularly in electric circuits. It is hoped the study shed some light on the teachers' classroom practices in schools in Gauteng.

Although the context of the participants was similar and they all had a perception that electric circuits is a difficult topic to teach, their classroom practices differed from one participant to the other. This could be because of the type of the in-service training offered by the district in that it focuses on what they know about the topic and little or no attention was paid to teachers on how to teach certain topics. The Department of Basic Education can use the findings of this research to plan ways on how to train their teachers to teach better in physical sciences, especially topics teachers perceive to be difficult.

5.4 LIMITATIONS OF THE STUDY.

- The study was limited to teachers who perceive electric circuits to be a difficult topic to teach in the Tshwane West District. Thus, it could not study teachers who perceive the topic to be easy to teach.
- Participated schools are no fee-paying schools with limited resources such as small or no laboratories, I would have been interesting to study other schools with all of the resources needed to teach the topic.
- The study was multiple case studies, this restricted the researcher to generalise the findings of the research (Creswell, 1994).
- The study was voluntary in nature, thus teachers who opted not to participate may have provided richer data.
- The study was conducted in only one district, which is the Tshwane West district.
- The study only focused on grade 12. Furthermore, research is needed at lower grades.

5.5 RECOMMENDATIONS

- The subject advisors should avoid encouraging teachers to finish the grade 12 curriculum by June. This notion encourages teachers to rush to finish the curriculum without learners understanding the content.
- The DBE should provide schools with sufficient laboratory equipment. This will assist learners to link theory with practice. For example, the use of circuit boards could have assisted learners to learn the topic of electric circuits better.
- The in-service training to balance on ‘’what’’ and ‘’how’’ to teach. This can be done by sharing not only the subject matter knowledge but also instructional strategies that teachers use to teach certain topics.
- The teachers to focus their accountability on the subject rather than on the system. This is because teachers who are accountable to the system teach for examinations and this lead to learners not understanding the concepts.

5.6. CONCLUSION

This study presented the nature of teachers' classroom practices in grade 12 classrooms in the Tshwane west district. Different factors emerged as the contributory factors associated with teachers' classroom practices. These factors ranged from teachers' teacher knowledge, instructional strategies, interactions and discourse and the type of accountability in the science classroom.

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APPENDICES
APPENDIX A

UNISA university of south africa

UNISA COLLEGE OF EDUCATION ETHICS REVIEW COMMITTEE

Date: 2018/06/13

Ref: 2018/06/13/60832576/02/MC
Name: Mr VJ Ramashia
Student: 60832576

Dear Mr Ramashia

Decision: Ethics Approval from 2018/06/13 to 2021/06/13

Researcher(s): Name: Mr VJ Ramashia
E-mail address: habinkateko@yahoo.com
Telephone: +27 82 077 6934

Supervisor(s): Name: Prof AV Mudau
E-mail address: mudauav@unisa.ac.za
Telephone: +27 12 429 6353

Title of research:

Exploring the nature of classroom practices when teaching electric circuits in a Grade 12 classroom. A case in the Tshwane West district

Qualification: M. Ed in Science and Technology Education

Thank you for the application for research ethics clearance by the UNISA College of Education Ethics Review Committee for the above mentioned research. Ethics approval is granted for the period 2018/06/13 to 2021/06/13.

*The **low risk** application was reviewed by the Ethics Review Committee on 2018/06/13 in compliance with the UNISA Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

2. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the UNISA College of Education Ethics Review Committee.
3. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
4. Any changes that can affect the study-related risks for the research participants,

APPENDIX B

GAUTENG DEPARTMENT OF EDUCATION APPROVAL

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	06 July 2018
Validity of Research Approval:	05 February 2018 – 28 September 2018 2018/150
Name of Researcher:	Ramashia V.J
Address of Researcher:	1510 Block H
	Soshanguve
	Pretoria, 0152
Telephone Number:	012 799 8564 082 077 6934
Email address:	habinkateko@gmail.com
Research Topic:	Exploring the nature of classroom practices when teaching electric circuits in a grade 12 classroom: A case in the Tshwane West District.
Type of qualification	Masters
Number and type of schools:	Four Secondary Schools.
District/s/HO	Tshwane West

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

06/07/2018

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

1

Making education a societal priority

Office of the Director: Education Research and Knowledge Management
7th Floor, 17 Simmonds Street, Johannesburg, 2001
Tel: (011) 355 0488
Email: Faith.Tshabalala@gauteng.gov.za
Website: www.education.gpg.gov.za

1. *The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*
2. *The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project*

APPENDIX C

LETTER TO REQUEST PERMISSION FROM THE DISTRICT

College of Education

Department of Science and Technology Education

Request for permission to conduct research at District.

Tittle: Exploring the nature of classroom practices when teaching electric circuits in a grade 12 classroom: A case in the Tshwane west district.

Date 08/03/2018

The District director
Tshwane west district.
012 799 8564

Dear Sir/Madam

I, Ramashia Vonani Japhta am doing research under supervision of Mudau A.V, a professor, in the Department of Science and Technology Education towards a Master's Degree with a specialization in Physical sciences at the University of South Africa. There are no funding involved. We are inviting you to participate in a study entitled Exploring the nature of classroom practices when teaching electric circuits in a grade 12 classroom: A case in the Tshwane west district.

The aim of the study is to investigate the nature of classroom practices when teaching electric circuits as perceived to be difficult topic. Your district has been selected because the main aim of the study is to investigate the nature of classroom practices when teaching electric circuits as perceived to be difficult topic and this can be achieved in your district. The teachers will be requested to sign the consent forms and give permission before the interviews and observations take place. To ensure that the process of researching does not disrupt the normal teaching and learning time, interviews will take place during school hours only when the teacher is free. The observations will also take place during school hours, in the classroom while the teacher is teaching. Audio-tapes will be used to record data during interviews and observations.

The benefit of this study is to improve classroom practices in the teaching of electric circuits and other topics teachers perceive to be difficult to teach in the Tshwane west district. The study will achieve this by identifying teaching difficulties and provide possible solutions. The names of the schools and teachers who will participate in the study will be kept confidential. Data collected in the study will be used for the purpose of the study only. Teachers have the rights to withdraw their participation any time. There will be no reimbursement or any incentives for the participation in the study. There is no potential risks anticipated in the study. Participants will receive a summary of research findings on request.

More information pertaining the study, please contact me on

Cellphone numbers: 082 077 6934 email: habinkateko@gmail.com

Or my supervisor Professor A.V Mudau :

Telephone numbers: 012 429 6353 email: mudauav@unisa.ac.za

Yours sincerely

Ramashia Vonani Japhta

Researcher

APPENDIX D

APPROVAL LETTER FROM DISTRICT

GAUTENG PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

Enq: HN Roestorff
Tel: 012 725 1414
Ref no: 8/4/4/1/2

To:	**The Principals of Selected Schools** **Tebogwane** **Fr. Smangaliso Mkhatshwa** **Wallmansthal** **Abel Motshwane** **Setumo – Khiba** **Tiyelelani** **MH Baloyi Secondary School**
From:	**P Galego (Ms)** **District Director**
Date:	**24th July 2018**
Subject:	**Request to Conduct Research: VJ Ramashia**

Please note that Ramashia VJ has been granted permission by Head Office to conduct research at the above-named schools. The exercise is scheduled for academic year 2018.

The school principals and SGB members are kindly requested to welcome the researcher.

Research Topic: **"Exploring the nature of classroom practices when teaching electric circuits in a grade 12 classroom: A case in the Tshwane West District."**

Please ensure that teaching and learning process is not negatively affected.

P Galego (Ms)
District Director
Tshwane West

"Enthusiasm Breeds Success"
Office of the Director – Tshwane West District
(Mabopane, Winterveldt, Ga-Rankuwa, Soshanguve, Kameeldrift, Rosslyn, Akasia, Pretoria North, Mountain View, Roseville, Capital Park, Hercules, Pretoria West, Lotus Garden)
Private Bag X38, ROSSLYN 0200. Tel (012)725 1300 Fax. (012) 725 1346
Paula.Galego@gauteng.gov.za; Web. www.education.gpg.gov.za

APPENDIX E

LETTER TO PROSPECTIVE PARTICIPANTS

UNISA university of south africa

College of Education

Department of Science and Technology Education

Date 08/03/2018

Tittle: Exploring the nature of classroom practices when teaching electric circuits in a grade 12 classroom: A case in the Tshwane west district.

DEAR PROSPECTIVE PARTICIPANT

My name is Ramashia Vonani Japhta am doing research under supervision of Mudau A.V, a professor, in the Department of Science and Technology Education towards a Master's Degree with a specialization in Physical sciences at the University of South Africa. There are no funding involved. We are inviting you to participate in a study entitled Exploring the nature of classroom practices when teaching electric circuits in a grade 12 classroom: A case in the Tshwane west district.

The study is expected to collect important information that could achieve the objectives of the study that is to investigate the nature of classroom practices when teaching electric circuits as perceived to be a difficult topic. You are invited to participate in the study because you are currently teaching Physical sciences grade 12 and you are working in the Tshwane west district. I do not have your contact details.

The study involves audio-taped semi-structured interviews and observations. The interviews will ask questions pertaining the teaching of electric circuits in grade 12. Each participant will be interviewed twice. The time allocation for each interview will be an hour. I hereby requesting you for your permission to use audio-tape recording while observing you teaching in the classroom and during interviews.

Participating in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason. There are no potential benefits in the study. There are no negative consequences for participant if he/she participates in the research project. The information that you convey to the researcher will not be revealed to anyone and your identity will be kept confidential. Your name will not be recorded anywhere and no one will be able to connect you to the answers you give. Pseudonym will be used in reporting methods. Hard copies of your answers will be stored by the researcher in a locked cupboard for future research purposes and electronic information will be stored on a password protected computer. The researcher will destroy all information under his control one year after the completion of the study. There will be no receiving of payment or any incentives for participating in this study. Participants will receive a hardcopy of dissertation on request.

More information pertaining the study, please contact me on

Cellphone numbers: 082 077 6934 email: habinkateko@gmail.com

Or my supervisor Professor A.V Mudau on:

Telephone numbers: 012 429 6353 email: mudauav@unisa.ac.za

Yours sincerely

Ramashia Vonani Japhta

Researcher

APPENDIX F

QUESTIONNAIRE

I appreciate that you are taking the time to respond to this questionnaire. Feel free to ask for clarification.

Below is a list of physics topics found in the knowledge area Mechanics in the Grade 12 Physical Science curriculum. Tick the topic that you find most difficult to teach.

1. Momentum and Impulse	
2.Vertical projectile motion in one dimension	
3. Work, Energy & Power	
4. Doppler Effect (relative motion between source observer)	
5. Electric circuits	
6. Electrodynamics	
7. Optical phenomena and properties of materials	

Thank you for your time, again I appreciate

APPENDIX G:

IN-DEPTH SEMI-STRUCTURE INTERVIEWS

Section A

Pre in-depth semi-structured interviews

Teacher knowledge

Context

1. How long have you been teaching physical science and grade 12 in particular?
2. Why do you perceive electric circuits as difficult to teach?
3. What are you going to teach today?
4. What resources you have in your classroom that help you teach?
5. What is your opinion on the general performance in physical science?
6. What is the socio-economic background of your students?
7. How long is your period?
8. Which languages do your students speak?
9. What is your class size in most cases?
10. How many progressed learners in your class?

Students understanding

1. What prior knowledge do learners need to learn electric circuits better in grade 12?
2. Do you know of any misconceptions learners might have? If yes, how do you correct them?
3. Are your learners interested to learn physical sciences?

Content knowledge

4. Consider the diagram below to answer the following questions

5.1 How do you explain the difference between series and parallel connections?

5.2 What would you say to a learner who say?

5.2.1 When the switch is opened(s) the voltmeter reading is 12.9V?

5.2.3 When the switch is closed the 4ohms resistor will receive the same current as the 5ohms resistor?

5.2.4. R1 receive the potential difference of 15V?

6. Both the potential difference and EMF are measured in volts. What is the difference between these concepts?

Section B

Instructional strategies

1. The following are broad teaching strategies: the process, didactic, discovery, activity driven, inquiry and conceptual change. From these tell me the ones you know and briefly talk about them

2. What didactic methods of teaching do you know/remember?

3. Which ones do you use? What is the reason for using the method you indicated? 4. Representations include amongst others: examples, models, analogies. Briefly talk about them. Which one did you use? How would you have used it?

5. Activities amongst others include: demonstrations, simulations, investigations and experiments. Briefly talk about them. Which one did you use? How would you have used it?

Section C

Interactions and Discourse

1. When you are presenting a lesson, do you ask questions to evaluate or to develop a lesson?

2. Given this type of communicative approaches dialogic-authoritative and interactive-non- interactive, which one do you think you use? Explain.

3. Which pattern of discourse (initiation, response and feedback / initiation, response, feedback, response and feedback) do you use in your classroom?

Section D

Accountability

1. How does the need to cover electric circuit in four hours shape your teaching?
2. Do you comply with weekly informal test? If yes, how does it shape you teaching?

3. When you teach learners, do you teach them to understand or for examinations? Please explain.
4. What would you say to a subject advisor who say you are left behind with the annual teaching plan?
5. Do you have progressed learners in your class who failed physical science in grade 11? If yes, how do you ensure that they close the content gap?
6. Do you teach progressed learners with the high flyers using the same strategies?
7. How often do you assess you learners?
8. How do you assist learners who fail your assessment?

Thank you for your time, again I appreciate it

Post in-depth semi-structured interviews

Teacher knowledge

1. Did you achieved your lesson outcomes for the lesson?
2. How does the socio-economic background of your students influence your teaching?
3. Do the language of your learners affects your teaching?
4. What resources would you have besides the ones you used to teach electric circuits?
5. What instructional strategies did you used?
6. What communicative approaches did used?
7. The type and pattern of discourse you used?
8. Do you think you taught learners to understand and/or to complete the syllabus?.

Thank you for your time, again I appreciate it.

APPENDIX H:
OBSERVATION TOOL

Aspects to be observed.

1. Teacher knowledge

1.1 The organisation and amount of subject matter knowledge

1.2 The number of learners in class

1.3 The length of the period

1.4 Learners linguistic abilities

1.5 The use of prior knowledge

1.6 How misconceptions are corrected

----

2. Instructional strategies

2.1 Explanatory framework (Analogy/Illustration)

…………………………………………………………………………………………

…………………………………………………………………………………………

2.2 Epistemological perspectives (Rationalism/Empiricism)

……………………………………………………………………………………
……………………………………………………………………………………

2.3 Activities (Problems/ Experiments/ models/examples/simulations/Investigations)

……………………………………………………………………………………
……………………………………………………………………………………

2.4 Didactics (lecture/Demonstration)

……………………………………………………………………………………
……………………………………………………………………………………

3. Interactions and Discourse

3.1 The type and patterns of discourse(Authoritative/ Dialogic/ Reflective)

……………………………………………………………………………………
……………………………………………………………………………………

3.2 Communicative approach(Interactive, authoritative/ Interactive, dialogic/ non interactive, authoritative/ interactive, authoritative)

……………………………………………………………………………………
……………………………………………………………………………………

3.3 Teacher questioning (Evaluative/ Lesson development)

……………………………………………………………………………………
……………………………………………………………………………………

4. Accountability (system/subject/student)

……………………………………………………………………………………
……………………………………………………………………………………

APPENDIX I

CASE 1 INTERVIEWS TRANSCRIPT

Interview transcript of Mr Phakama at Habalelwi Secondary School

Mr Phakama = P

Researcher = R

Line	Interview transcript
1.	Researcher(R): Good morning Mr. P?
2.	Participant(P) : Morning sir
3.	R: and how are you?
4.	P: I am fine thanks and you?
5.	R: I am fine
6.	R: firstly, allow me to thank you for voluntarily taking part in this research. Again, please
7.	note that the information that you will provide will only be accessed by myself (R). In
8.	addition, remember that you have the right to withdraw from participating at any time.
9.	Now can we start with the interviews?
10.	P: yes, we can sir
11.	R: Please tell me about your qualifications
12.	P: I am have a B ED degree natural sciences, with Physical science and Mathematics as
13.	two major subjects…..I also have a B ED(Hons) degree specializing in physical sciences
14.	R: How long have you been teaching physical science and grade 12 in particular?
15.	P: “I think is the sixth year now, since 2013.
16.	R: sixth year since 2013.
17.	R: and grade 12?
18.	P: six years in grade 12
19.	R: so you have six years in teaching and six years teaching grade 12?
20.	P: No, I have seven years in teaching but six years in grade 12
21.	R: ok, thank you very much.
22.	R: P I see you ticked electric circuit as a topic you perceive to be difficult to teach, why
23.	do you perceive electric circuits as a difficult topic to teach?
24.	P: Because of the fact that leaners do not understand how to deal with series and that
25.	parallel networks. That is their problem. They do not know how to apply the knowledge
26.	they have on series and parallel networks. Say for an example if you are given two

resistors in parallel and one in series with the parallel resistors, so you have a parallel-Series connection. Now learners will not pick up that the resistors that are in parallel will have the same potential difference and if you add that potential difference to the one, which is connected in series with the parallel connection, then it, should give you the total external voltage or potential difference. Most of them will add the two, and will see that the resistors in parallel have the same potential difference but then in terms of the total they add the two in parallel together with the one in series. Now they find out that the value is now bigger than what the battery is actually supplying.” So briefly, misconceptions and pre-knowledge makes the topic difficult to teach.

R: Thank you

R: Tell me, what are you going to teach today?

P: “I’m going to start with electric circuits, doing grade 8,9,10 and 11 revisions, to check whether they still remember them. Will talk about connections, how voltmeters and ammeters should be connected and then we will touch a bit on ohms law as well as Ohmic and none-Ohmic conductors.”

R: What resources do you have in your classroom that helps you teach the topic?

P: “We are using a smart board; it enables us to have or to demonstrate a video science demonstration of experiments that are done at a lab. We also have in position a physical lab which I think can also assist as well, but here we have a problem with lack of apparatus then we make use of videos to ensure that we are able to show them what to do.”

R: So in other words, where you do not have enough resources, learners are no longer going to do the experiment but are going to watch on how the experiment is done?

P:“That is how we improvise.”

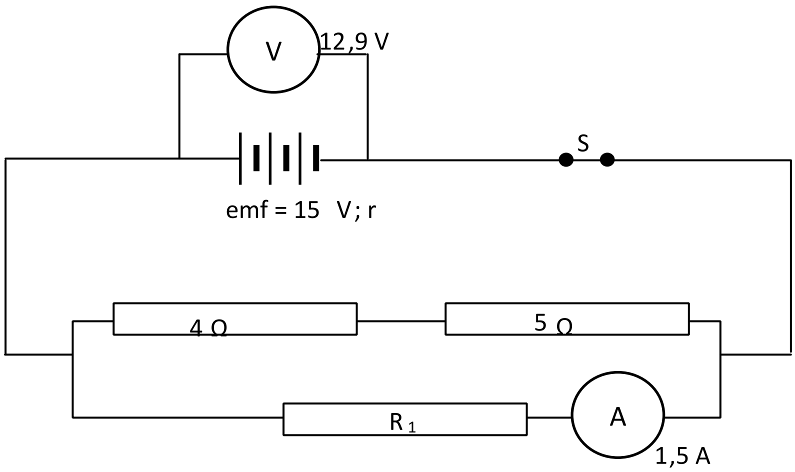
R: What is your opinion on the general performance in physical science?

P: “In physical science as a subject, the performance is not that good. Because of many factors that are contributing which include chapters/topics which teachers perceive difficult to teach .and those that leaners find difficult to understand because of the way

that the teacher is approaching the teaching of that particular topic.so it becomes the
subject where we have poor performance. In other places, it is also acceptable that
leaners should not perform well in physical science because it is difficult and it is an
accepted norm that science is difficult. So they don't expect students to do well in
physical sciences."
R: so teachers approach in teaching is central to poor performance in the subject
P: Yes, it is the main contributing factor.
R: What is the socio-economic background of your most students in your school and
class in particular?
P: "Some of them are from squatter camps, some are from around here and some of
them are orphans. So its child headed families. Some of them are from divorced
families."
R: So you think those contextual factors that you have mentioned play a role?
P: "They play a huge role because parents should assist the educators, now how are
they going to assist the educators if they are not there? So you don't have any parental
involvement. You find that now the educator has to do everything himself. He has to
make sure that when the learner is at home, the learner does the work." And even if
they are there some are having fights so they are not helping the child. This affects the
child psychologically.
R: How long is your period, and how many do you have today?
P: "Our periods are 30 minutes long, so today I have a double period which means I
have an hour."
R: Which languages do your students speak?
P: "All students are Tshwana speaking people."
P: "Our periods are 30 minutes long, so today I have a double period which means I
have an hour."
R:What is your classroom size?
P:"Maximum 35 leaners in a classroom, we have small classes even if we wanted to
accommodate more we cannot because it will reach carrying capacity."
R: What is your view on progressed learners?
P: "In terms of progression I don't think that mathematics and science should have

85.	progressed learners because this subjects on their own they are very heavy for learners.
86.	You find that learners who are not progressed, who have passed the subject since grade
87.	10, when they reach grade 12 they fail it. How worse do you think the progressed
88.	learner who has never passed the subject before will perform? So I think that they have
89.	to look at this and maybe progress learners in specific subjects and then not in other
90.	subjects because now when it comes to physical science and mathematics progressed
91.	learners I do not think ever since we introduce progress learners the pass percentage
92.	of progress learners reach 10%. A few may make it but what about the remaining 90%.
93.	We are saying to them that we will modularize you. You will have multiple opportunities
94.	to write maybe next year and the year after that but then who is going to be teaching
95.	them the subject because physical science is a subject where there should be
96.	continuous interaction between the educator and learner. So if the learner is alone
97.	he/she cannot pass the subject or if the learner attends twice a week he/she cannot
98.	pass a subject because he/she failed while attending everyday even on Saturdays."
99.	R: Do you have progressed learners in your class this year?
100	P: "This year I don't have any progressed learners in my class because learners are no
101	longer allowed to change in grade 12 from mathematics to mathematical literacy. Yes
102	in the past, we use to have. We knew that even if learners fail science they will pass
103	Mathematical literacy and the school would have a higher pass percentage. Since the
104	policy that says, learners should not do physical science and mathematical literacy, ever
105	since then when we progress learners and we give them some sort of a conditions.
106	which they can refuse to say since you failed physical science and mathematics there is
107	no way in which in grade 12 you will pass them because you are progressed and you
108	have obtained less than 20% on both subjects so we are saying to you let us now take
109	one of them away from you so that you will have more time to focus on the other so

110	now they cannot change mathematics to mathematical literacy. We progress them but
111	they will do Tourism instead of physical sciences.”
112	R: Why Tourism
113	P: Because they can easily pass, the subject and the school will have a high pass
114	percentage.
115	R: Let us go to Student understanding
116	R: What prior knowledge do learners need to learn electric circuits better in grade 12?
117	P:“They need to know components of a circuit both visually and symbolically, know how
118	those components should be connected in a circuit that is the prior knowledge, they
119	should also know and master ohms law, and they should know and master factors
120	affecting resistance and the relationship between Resistance, Voltage and current. They
121	should also know how to work with graphs to say when potential difference changes
122	then the current changes as well, what is the relationship between the two? We can
123	write it down symbolically, we can also write it down in words stating ohms’ law and
124	we can write it down graphically. The same law can be interpreted in three different
125	ways, they should know how to interpret it in three different ways and they should also
126	have knowledge in working with series and parallel networks because I believe high
127	school circuits from grade 10 to 12 are about series and parallel networks.”
128	R: Do you know of any misconceptions learners might have? If yes, how do you correct
129	them?
130	P: Same as question number 2. To correct the misconceptions, I use analogies. The
131	danger of analogies is when you do not explain how analogies relate to concepts.
132	Thank you
133	R: Are your learners interested to learn physical sciences?
134	P: “They are very much interested. They know that when they get to grade 10 and start
135	doing physical sciences, they are going to do interesting things.”
136	R: Do you have learners doing physical sciences and mathematical literacy?
137	P: “No”, policy does not allow.
138	R: Let us now focus on Content knowledge while referring to the diagram.

139	
140	R: How do you explain the difference between series and parallel connections?
141	P: “Series and parallel networks are usually about potential difference and current, so
142	when we say we have a parallel connection of devices we are going to say that it’s a
143	connection in which the parts connected have the same potential difference. Series
144	network devices are connected in such a way that devices they have the same current,
145	here if you connect an ammeter in any point you will find that the current is the same.”
146	R: What would you say to a learner who says?
147	R: When the switch (s) is opened, the voltmeter reading is 12.9V?
148	P: “Series and parallel networks are usually about potential difference and current, so
149	when we say we have a parallel connection of devices we are going to say that it’s a
150	connection in which the parts connected have the same potential difference. Series
151	network devices are connected in such a way that devices they have the same current,
152	here if you connect an ammeter in any point you will find that the current is the same.”
153	R: When the switch is closed the 4 Ohms resistor will receive the same current as the 5
154	Ohms resistor?
155	P: “I would say that is correct, based on the diagram we see that the 4 Ohm resistor and
156	the 5 Ohm resistor are connected in series.”
157	R: Resistor (R1) receives the potential difference of 15 V?
158	P: “I would say it’s incorrect based on the fact that 15 volts is the electromotive force
159	and this is the total energy per coulomb of charges that the battery supplies and this

battery does not only supply the external resistors but it also supplies the internal resistors. There is opposition of charges to flow within the battery, which means between the two terminals of the battery there is difference in potential energy caused by the internal resistance. The internal potential difference should take its own contribution of the 15 because it’s like any other resistor connected in series to this particular circuit diagram.”

R: it sounds like the internal resistance plays an important role, Can you explain your general understanding of the internal resistance?

P: “I draw a wire and put a resistor in between and we define that resistor to say its opposition of charges to flow which means anywhere where I have charges flowing there is possibility that those charges would be opposed, between any two points in that wire there will be difference in potential energy. One point in the wire will have a high potential energy and another point will have low potential energy so between the two points there will be a difference in potential energy. Because of the presence of the resistor, those two points have different potential energy so. In a battery between the two terminals when the charges flow from one terminal to the other, within the battery itself there is opposition of the charges to flow they don’t flow smoothly because of the chemical reactions that are taking place accounting to why there should be opposition. Because of the opposition of those charges to flow between two terminals of the battery, there is high electron potential energy and in another terminal, there is low electron potential energy. When you measure the differences between the two you then work out what the actual internal resistance is.”

R: Both the potential difference and the Electromotive Force are measured in volts. What is the difference between these concepts?

P: “The EMF is measured in volts because when you define the volt you will be talking about the work done per unit charge so if the charges that are there are doing work

186	then you have potential difference which you say you have a volt because of the work
187	done per coulomb of charge. When you look at the battery there are charges flowing
188	within the battery so there is work done per each coulomb of charge that is transferred
189	from one terminal to the other, so you will say the EMF is the electro motive force for
190	the battery because of the work done per coulomb of charge that passes specifically
191	through the battery. When you look at potential difference between any two points in
192	a circuit where there is a resistor connected or even if there’s no resistor connected
193	you will say I have zero potential difference because the potential energy in one point
194	is the same as the potential energy on the other point because there is no resistance.”
195	R: let us now go to Section B
196	R: section B deals with the Instructional strategies you use in the classroom.
197	R: The following are broad teaching strategies: the process, didactic, discovery, activity
198	driven, inquiry and conceptual change. From these tell me the ones you know and
199	briefly talk about them.
200	P: “For an example I will be teaching electric circuits where I will be engaging with the
201	learners in direct instruction which is part of the didactic. From there learners will
202	inquire about what is happening within that specific topic and from that enquiry they
203	get to discover some of the things on their own because they made enquiry and there
204	were didactic principles that were applied in teaching like direct instruction. We then
205	give them activities because we want to drive home discovery and we want them to
206	inquire more. How are they going to inquire more if we don’t give them activities?”
207	R: What is your view on the use of lecture method as a teaching strategy in science?
208	P: “Lecture method in isolation cannot solve anything especially in the teaching of
209	science, it cannot work. It must be incorporated with other methods such as discovery,
210	inquiry and conceptual change.”
211	R: Representation includes amongst others: examples, models, analogies. Briefly talk
212	about them. Which one did you use? How would you have used it?

213	P "I have already explained some of these questions. I use models as they are of
214	importance so that learners are able to see what I am talking about. I also use analogies
215	in circuits."
216	R: Activities amongst others include demonstrations, simulations, investigations and
217	experiments. Briefly talk about them. Which one do you use?
218	P: "Usually I use demonstration and some simulations we also do experiments but due
219	to lack of resources we do a few experiments.
220	R: let us now focus on Section C
221	R: The Interactions and discourse
222	R: When you are presenting a lesson, do you ask questions to evaluate or to develop a
223	lesson?
224	P: "For a lesson to develop you must ask a lot of questions so yes I do ask questions to
225	develop a lesson."
226	R: Given this type of communicative approaches: interactive-authoritative, non-
227	interactive-authoritative, interactive-dialogic and non- interactive-dialogic, which one
228	do you think you use? Explain
229	P: "I use the interactive-dialogic communicative approach, we interact and then there
230	will be dialogue. When I start a lesson, I interact with the learners. I ask them questions
231	and then they respond which leads to an interactive dialogue based on the concept."
232	R: Which pattern of discourse (initiation, response and feedback (IRF)/ initiation,
233	response and feedback, response and feedback (IRFRF) do you use in your classroom?
234	P: "I use the initiation as a teacher, response from the learner, feedback from the
235	teacher, response from the learner and feedback from the teacher pattern of
236	discourse."
237	Section D
238	Accountability
239	R: How does the need to cover electric circuit in four hours shape your teaching?
240	P:"I cannot cover electric circuit in four hours because for me four hours is for
241	introduction."
242	R: Would you recommend that the time allocated to teach electric circuit should be
243	increased?
244	P:"According to me the time should be increased because there are a lot of things to be

245	covered and you should teach them to understand.”
246	R: Do you comply with weekly informal test? If yes, how does it shape your teaching?
247	P: “I do not comply with weekly informal tests. If I want to drive a specific concept, I can
248	test them any time even on three consecutive days. They can write ten tests in one
249	week it depends on how much work I have covered.”
250	R: When you teach learners, do you teach them to understand or for examinations?
251	Please explain.
252	P: “I teach learners to understand and if they understand then they will pass
253	examinations.”
254	R: What would you say to a subject advisor who says you are left behind with the annual
255	teaching plan?
256	P: “I will tell the advisor that I am not teaching annual plan, I am teaching physical
257	sciences. If you want to see the results come when they write June and final
258	examinations, and check whether they are going to pass or not.”
259	R: Do you have progressed learners in your class who failed physical science in grade
260	11? If yes, how do you ensure that they close the content gap?
261	P: “I don’t have progressed learners in my class, I only have learners who failed physical
262	science in grade 11 but they are not progressed because they passed other subjects. To
263	cover the content gap you must bring back what was taught in previous grades when
264	you teach.”
265	R: How do you asses your learners?
266	P:“They can write ten tests in one week it depends on how much work I have covered.”
267	R: How do you assist learners who fail your assessments?
268	P: “I get to the root of the problem why they are failing the assessment, sometimes you
269	find that there is a specific misconception and you find that it is common on all the
270	learners that are failing. Once I identify and solve the problem then learners are able to
271	pass. I also use high flyers in order to assist.”
272	R: In the Tshwane west district, subject facilitators adopted #45 where they encourage
273	that schools must ensure that all learners get 90 marks out of 300. Electric circuit is
274	allocated three marks on the document. What is your take on that?
275	P: “Maybe they are adopting it for learners somewhere, not for our learners because I

276	believe that if a learner has performed poorly in physical sciences then the learner got
277	50% as that is the minimum at tertiary institution. I say #70% not 70 marks let us
278	challenge learners to get more."
279	<u>Post interviews</u>
280	R: P, do you think you have achieved the lesson outcomes?
281	P: yes, I think I did. Maybe you realised that learners slowly were grasping the concepts
282	as the lesson proceeds.
283	R: I heard you are using Kirchhoff's law to explain the split of a current and it is not in
284	the curriculum, why so?
285	P: The law is important to internalize the concepts. The law gives a clear understanding
286	as to how the current is split in the current when we look into parallel connection.
287	R: You used the analogy to explain the current split, don't you think it might create
288	misconceptions that the greater the opening the greater the resistance in the draws,
289	Despite your explanation?
290	P: No, I strongly emphasized that with electric circuit it is different, the greater the
291	Resistance the smaller the current.
292	R: When internalizing the concepts, you used parallel-series networks only, do you think
293	They will understand if given series-parallel networks?
294	P: Yes, they will. It is a matter of understanding the characteristics of each circuit.
295	R: If given more time to teach the topic, what more will you teach?
296	P: Giving more activities that involve both parallel-series and series-parallel
297	Connections.
298	R: Do you think the introduction of internal resistance makes the topic difficult for you
299	To teach?
300	P: Yes, yesterday I just taught them that $V_T = V_1 = V_2$ in parallel connection, now today
301	I had to further indicate that there is Internal resistance within the battery.
302	R: How do you think we can solve this problem of internal resistance?
303	P: We should start teaching it in Grade 10 and 11.

APPENDIX J:
CASE 2 INTERVIEWS TRANSCRIPT

Researcher: “Ehrr… Good morning Mr Dakalo”

Mr Dakalo: “Ehrr… Good morning Sir.”

Researcher: “And how are you?”

Mr Dakalo: “I’m good thanks, and you?”

Researcher: “I’m good. Please allow me to first thank you for participating in this research. Please note that all the information I will gather as a Researcher, it is confidential and it will only be accessed by myself only. Ehrr… without any time wasting, I would like us to start with the questions at pre indepth semi-structured interviews. Mr Dakalo, please tell me about your qualifications.”

Mr Dakalo: “Ehrr… My qualification. I have B at FET Honours in Education specializing in Mathematics on TUT.”

Researcher: “No, thank you very much Mr Dakalo. Ehrr… how long have you been teaching Physical Science and Grade 12 in particular?”

Mr Dakalo: “Ehrr.. 4 years Sir.”

Researcher: “4 years. You have been teaching for 4 years and you have been teaching Grade 12 for 4 years.”

Mr Dakalo: “For 4 years. Yes.”

Researcher: “Ok. Thank you very much. Mr Dakalo, why do you perceive Electric Circuit as a difficult topic to teach?”

Mr Dakalo: “Because teachers they are not teaching or explaining the type of connection very well to kids. That makes it difficult to understand.”

Researcher: “Oh ok. Thank you very much. Ehrr… what are you going to teach today?”

Mr Dakalo: “Electric Circuit.”

Researcher: “Ehrr.. What resources do you have in your classroom that will help you teach the topic?”

Mr Dakalo: “I will be using textbooks, chalk board, previous question papers to prepare my lesson and present it.”

Researcher: “Oh ok. No. Thank you very much. What is your opinion on the general performance in Physical Science?”

Mr Dakalo: "Ehrr... The general performance in Physical Science it's not doing good, its average. Even if you can look at the national performance of physical science, you will see that its average. It's not doing that very good."

Researcher: "Ok thank you very much. Then tell me Mr Dakalo, what is the socio economic backgrounds of most of your learners in your school, the whole school and particularly in your classroom?"

Mr Dakalo: "It's that learners come from another province. They travel from long distance from North West come to Gauteng using different transport and they come from a very poor background. Ehrr… some children come from child headed family. Which contribute to teaching, you see?"

Researcher: "Can you explain maybe how do they contribute to teaching?"

Mr Dakalo: "They contribute very bad because some of them they need psychologists to take them through the headed family backgrounds because it also affect to the teaching because most of them you find out that they are not concentrating in class. They are thinking about their problems more than the content, making it very difficult."

Researcher: "Ok. Thank you very much. Ehrr… How long is your period and how many do you have for today?"

Mr Dakalo: "Ehrr… Normally, in our school, periods goes by 30 minutes and today I'm having 2 periods which will lead me to one hour."

Researcher: "Oh. Thank you, thank you very much. And then, ehrr, which language or languages do your learners speak?"

Mr Dakalo: "Ehrr.. Most of the time they speak Tswana. 90% of them its Tswana then the rest its other languages like Zulu, a little bit of Sepedi and others."

Researcher: "Oh ok. And what is your classroom size in most cases?"

Mr Dakalo: "40 learners in class."

Researcher: "You have 40 learners?"

Mr Dakalo: "Yeah. Overcrowding as you can see (giggles)."

Researcher: "It's over crowded. (giggles) Thank you very much. Ehrr what is your view on progress learners?"

Mr Dakalo: "Ehrr… My view is that they add to failure rate and the ATP the way it's been structured does not cater for them. Because you really need to cover the ATP and while they are left behind."

Researcher: "So the ATP contributes a lot?"

Mr Dakalo: "They contribute a lot to this progress learners. That is why they would progress because of ATP was not covered even in Grade 11. So they always have a contact gap from the previous scripts."

Researcher: "Alright! Thank you, thank you very much. Let's go to student understanding, what prior knowledge do learners need to learn Electric Circuit that are in Grade 12?"

Mr Dakalo: "Ehrr… They need the Grade 10 and 11 knowledge of electric circuit which includes Ohm's law, ohmic conductor, non-ohmic conductor, power and energies."

Researcher: "Thank you. Thank you very much. And then do you know of any misconceptions learners might have and if 'YES' how do you correct them?"

Mr Dakalo: "I think the misconception behind these learners is that they think that the brightness of the bulb is controlled by current. Whereas in reality it's controlled by the potential difference that is supplied by the battery."

Researcher: "How would you correct that?"

Mr Dakalo: "By giving example of real life situation according to the way izinyoka is being connected to other areas. For example, Tembisa. And when we are talking about, even in class, the way these lights are connected. Because they are glowing in the same brightness, it simply tells about the potential difference that is there."

Researcher: "So in a nutshell, the example you made now it tells us that the potential difference here in our office is the same"

Mr Dakalo: "It's the same. Because it is also connected in parallel and the potential difference that is supplied there is the same. Ya, when we are talking about other places like Tembisa, the potential difference as it is connected in series it is not the same throughout."

Researcher: "Oh ok. Thank you very much. Ehrr… are your learners interested to learn Physical Sciences?"

Mr Dakalo: “Yes. Because they love the subject and they don’t bunk classes. And they want to pursue careers that include Physical Science.”

Researcher: “Oh ok. Thank you very much. Do we have learners doing Physical Science and Mathematical Literacy?”

Mr Dakalo: “Yes and those learners are not performing that very good, because there are some questions there, in Physical Science, that they need Mathematics concept such as calculations that involve simultaneous equation. And making subject of the formulas, it becomes a challenge to them.”

Researcher: “So how many do you have?”

Mr Dakalo: “24 in a class of 40.”

Researcher: “24! You have a lot of progress learners in your class. Ehrr… let’s go to content knowledge. We are going to consider this diagram Mr Dakalo. This diagram we have the EMF of 15 volts with V measuring 12,9 V. We have 4 Ohm resistor and 5 Ohm resistor and also have R1 and A with 1,5 Amperes. Now how do you explain the difference between series and parallel connection?”

Mr Dakalo: “The difference is that series connection, the current that is passing through a connection is the same throughout. And the potential difference across that connection is different. And then on parallel connection, the current that is passing there its divide according to the proportion of the resistors, and the potential difference 0n the parallel connection is the same. So that’s how I’ll explain the difference between the 2.”

Researcher: “Ok, thank you. Let’s look at the diagram again, what would you say to a learner who would say when, ‘when switch S is open, the volt meter reading is 12,9V’?”

Mr Dakalo: “I’ll say….ehrr… that is a wrong way to view that because no current is flowing in the circuit. So V cannot measure 12,9 volts because there is no current flowing in the circuits.”

Researcher: “What would be the correct answer there?”

Mr Dakalo: “It would be 15V.”

Researcher: “Why 15?’

Mr Dakalo: "Because the voltage would just be measuring the EMF of the battery only."

Researcher: "Again, what would you say to another learner who would say the switch is closed, the 4 ohm resistor will receive the same current as the 5 ohm resistor?"

Mr Dakalo: "I'll say very good my child because you now understand the different type of connection because in a series connection, current that is passing there is the same current at 4 ohm and at 5 ohm."

Researcher: "So are you now saying that the 4 ohm and the 5 ohm are connected in series?"

Mr Dakalo: "Yes."

Researcher: "Ok. Thank you very much. Ehrr… What do you say to a learner who would say resistor R will receive the potential difference of 15V?"

Mr Dakalo: "I would say, my child, that answer is not relevant because that is an EMF (Electro Motive Force). It's the potential difference before the voltage could be distributed to the external circuit."

Researcher: "So do you care to explain why the battery does not supply the 15V and supply 12.9V instead?"

Mr Dakalo: "Yes, because I'll explain to tell them to say that inside the battery there is an internal resistance before the voltage could be distributed to the external circuit. Therefore the internal resistance will reduce the voltage."

Researcher: "Ok. Thank you very much. Ehrr.. both the potential difference and the EMF are measured in volts. What is the difference between these 2 concepts?"

Mr Dakalo: "The potential difference is the voltage of the external circuit after it is being reduced by the internal resistance. And then the EMF is the voltage of the battery before it can be reduced by the internal resistance."

Researcher: "Ok, thank you very much. Let us go to section B, the instructional strategies. The following are broad teaching strategies; the process, the diag discovery, activity driven enquiry and conceptual change. From these, tell me the ones you know and briefly talk about them."

Mr Dakalo: "Ehrr… Activity Driven. Because its when I give learners the activities and learners do the activities and I drill them on those activities and I prefer them in Physical Science because Physical Science is a driven subject. You must drill these kids on the activities so that they get the concept."

Researcher: "So when you drill these learners are you using the textbook questions or the examination questions?"

Mr Dakalo: "I use them both. I first start with the textbook, then lead to examination questions so that they can see the difference and how the question paper is set."

Researcher: "And do you think there is a difference between the questions on the textbook and the previous question papers?"

Mr Dakalo: "Not that much of a difference because they differ. Textbooks they differ. Not much of a difference because of different textbooks we use."

Researcher: "Ok, Anything you want to add with respect to the teaching strategies?"

Mr Dakalo: "No. that one is fine."

Researcher: "Ok. Thank you very much. What is your view on the use of lecturer method as a teaching strategy in Science?"

Mr Dakalo: "In our school I should say it is incorrect to use that strategy. Why should I say that because learners need to work so that they can see the different types of questions and know how to approach these questions on their own? If I'm the one who is doing the talking, then learners won't get to see the difference of the questions."

Researcher: "No. Thank you very much. Representations, include among others, examples, modules, analogies. Briefly talk about them. Which one do you use and how do you use them?"

Mr Dakalo: "I prefer to use examples and analogies. Why examples and analogies? I use examples because example is the only way to teach. I use them to explain. And then analogies, I will use that to introduce the topic."

Researcher: "Ehrr… Do you have any analogy that you want to use for a specific concept?"

Mr Dakalo: “I have different analogies that I can use. I can make use of, when teaching electric circuit for example, by showing learners how to understand the resistance or the resistor part by giving them analogy either of water or of learners wanting to pass the door at the same time. When learners want to pass the door at the same time they don’t be able to pass at the same time because the door doesn’t allow many learners to pass the door at once. Then if it doesn’t allow, it resists them from passing. Therefore, that’s how I would introduce the topic of resistors.”

Researcher: “So the door in that case would therefore represent resistance?’

Mr Dakalo: “It will therefore represent resistance. The smaller the door, the bigger the resistance. The bigger the door, the smaller the resistance. It allows people to pass. The analogy would be people as charges.”

Researcher: “So those people will not be able to pass through the door?”

Mr Dakalo: “Yes. At the same time. So they need to pass one-by-one. So that’s how I use my analogies.”

Researcher: “Ok. Thank you very much. Ehrr… Activities, among others they include demonstration, simulation, investigation and/or experiments. Briefly talk about them, which one do you know or which one do you use?”

Mr Dakalo: “I use demonstration because I demonstrate by giving them examples. Start by giving them notes then comes with examples then demonstrate different types of questions. How to answer them and how to approach those questions. Then that is why I prefer and use demonstration.”

Researcher. “Ok, no. Thank you very much. Now let us go to Section C, the interaction and discourse. When you are presenting in the lesson Mr Dakalo, do you ask questions to evaluate or to develop a lesson?”

Mr Dakalo: “I ask questions to evaluate because I need to evaluate whether they do understand or not by posing questions.”

Researcher: “Given these types of commutative approaches; interactive authoritative, non-interactive authoritative, interactive dialogic and non-interactive dialogic, which one do you think you use and explain?”

Mr Dakalo: “I use interactive dialogic because I give learners the opportunity to interact and ask questions during the presentations so that we correct one another and they can correct themselves during the presentation.”

Researcher: “Thank you very much. Which pattern of discourse do you think you use amongst authoritative, dialogic and reflective?”

Mr Dakalo: “Dialogic. So that learners can engage and interact during the lesson. There must be an interaction and learners must engage themselves during a presentation.”

Researcher: “Thank you. Which pattern of discourse; initiation, response and feedback or initiation, response and feedback, response and feedback do you use in your classroom?”

Mr Dakalo: “I use initiation, response and feedback and response and feedback approach. Why? As I have said that the lesson would be interactive dialogic and I’ll use a pattern of dialogic and then I will use that because I’ll be taking learners’ answers from leaners’ response. After responding then I pose another question back that’s how I’ll be formulating another question to check the understanding, clarity and assurance whether they get the concept.”

Researcher: “Thank you very much. Let us go to the last Section, which is the accountability. How does the need to cover electric circuit in 4 hours shape your teaching?”

Mr Dakalo: “I really don’t consider time when teaching because I teach learners to understand. I don’t teach to cover the topic, I make sure that they understand.”

Researcher: “Oh, so do you comply with weekly informal test and if ‘yes’, how does it shape your teaching as well?”

Mr Dakalo: “I comply with them because it’s an instruction from the above. I don’t have a choice. But it makes me to teach faster.”

Researcher: “Teaching faster in what way?”

Mr Dakalo: “Ya. Which made me end up to moving at the speed of light and not end up, learners will not end up getting the concept. But I prefer to teach without considering time.”

Researcher: “When, you teach learners, do you teach them to understand or for examinations?”

Mr Dakalo: “As I have said, I teach them to understand so that they will be able to approach any type of question and be able to master the subject and pass the examination. I don’t teach for examination but to understand.”

Researcher: “Ok, thank you very much. Ehrr… What would you say to a subject advisor who says you are left behind with the annual teaching plan?”

Mr Dakalo: “I will say, Sir, learners need to understand the content and the concept rather than rush to finish the ATP without understanding. That would result in 0% pass rate. So if they understand, they would rather be behind but all the questions that they will answer will be correct.”

Researcher: “Thank you very much. Do you have progress learners in your class who failed Physical Science in Grade 12 and if ‘yes’ how do you ensure that you close the content gap?”

Mr Dakalo: “Yes Mnr, eish. Because you know that kids you know kids they are slow but I try to give them Grade 11 work on the afternoons so that I can close the gap. Do revision with them, drill them over the questions.”

Researcher: “Oh so you are using the afternoon lessons to assist the Grade 11s content. What type of questions do you use to grill the afternoon lessons?”

Mr Dakalo: “I structure my questions. I first start with level 1 questions take Grade 11 work. Level 1 question couple that with Grade 12 work. Then when they understand Level 1 question now I move to Level 2. After that, I couple that. I don’t teach them Level 4.”

Researcher: “Thank you very much. Do you teach these progress learners in the afternoon? Do you teach these progress learners with high flyers using the stem strategies?”

Mr Dakalo: “I do that because it is the same class then I use the same method because if I don’t, then other learners will be behind. But I cater for high flyers as well.”

Researcher: “Using the same. So in a nutshell you are saying you are using the same strategy to present the lesson?”

Mr Dakalo: “I use the same strategy to present to the learners but when asking questions I use different strategies.”

Researcher: "Can you maybe give me an example of the strategies you will use to…."

Mr Dakalo: "The strategy that I use to give them question is that, progress learners have Level 1, with 2 questions, some of them 3. Then high flyers I give them all the questions. Give them smaller time to answer all the questions from Level 1 until level 4 because they really need to be fast and answer as many as possible. I give them a lot of work during activities."

Researcher: "Oh ok. How often do you assess your learners?"

Mr Dakalo: "Assessing these learners, according to their policy of Physical Science, I assess them every day. Daily class work, home works and weekly tests as I have to comply.

Researcher: "Oh ok. And how do you assist learners who fail your assessment?"

Mr Dakalo: "I use a different strategy or different method to explain the same concept. Or give them the same question from the classwork and change it a bit so that he/she can end up seeing the difference between the classwork questions and the assessment questions."

Researcher: "Can I add one more question. Do you have the Physical Science laboratory here in your school?"

Mr Dakalo: "Yes I have a Physical Science Laboratory that is functional. We do experiments in that."

Researcher: "It's working properly?"

Mr Dakalo: "It's working properly."

Researcher: "Oh ok. So there is nowhere during the teaching of this topic where you indicated that you would like to use the laboratory to perform the practicals or maybe the experiments?"

Mr Dakalo: "Ehrr… Some topics are its difficult to present the lesson using the experiments because we don't have enough apparatus and chemicals. Some we do but the school prefers to buy the material for the prescribed experiments."

Researcher: "Oh ok. But I see here according to the caps, the electric circuit is a prescribed experiment in Grade 12."

Mr Dakalo: "Yes that means we have the apparatus to do the experiment and based on the electric socket question so that we must not finish the potential difference of the batteries. Because if we keep on using that, we won't have enough batteries to do the experiments as prescribed?

Researcher: "And lastly Mr Dakalo, I see that Gauteng has introduced the paperless classroom where they have smart boards. Do you perhaps have one in your classroom?"

Mr Dakalo: "Yes we do have one and we use one during our lesson sometimes."

Researcher: "Oh ok. Thank you very much. I would like to join you as agreed. I would like to join you to your class and observe you teaching as per our agreement. But in terms of the in-depth semi-structured interview, we are done for today. Thank you very much Mr."

APPENDIX K:
CASE 2 INTERVIEWS TRANSCRIPT

Interviewer: "Good morning Mr. Tebogo."

Mr. Tebogo: "Good morning Sir, how are you?"

Interviewer: "I'm good, thanks and how are you?"

Mr. Tebogo: "I'm very fine, thank you Sir."

Interviewer: "I'm very well. Now before I take or we continue with the interview, I would really like to thank you for participating in this research. Please note that the information that you are going to provide will remain confidential. It is only myself as a researcher who will remain with access to that information."

Mr. Tebogo: "My pleasure Sir."

Interviewer: "Thank you very much. Now, I would like us to go through the interview questions. The first question is based on the Tita Knowledge Section A. The contextual factors. Mr. Tebogo, how long have you been teaching Physical Science and in particular Grade 12?"

Mr. Tebogo: "I have 3 years."

Interviewer: "3 years. And teaching Grade 12?"

Mr. Tebogo: "Yes, I'm teaching Grade 12."

Interviewer: "Ok. So its 3 years in teaching and 3 years in teaching Grade 12?"

Mr. Tebogo: "Grade 12, yes."

Interviewer: "Ok. Thank you very much. Ehrr… I see you ticked the topic Electric Circuits as a difficult topic to teach. Why do you perceive Electric Circuit as a difficult topic to teach?"

Mr. Tebogo: "Ehrr… It's because the topic is a topic that has been treated from Grade 10 until Grade 12. But there was not much variance in those 2 grades. But once you introduce the issue of internal resistance to learners, it becomes a problem. Because learners all they knew before it was the resistances in terms of series and parallel. Now if you introduce something new which is internal resistances, it starts to puzzle them."

Interviewer: "Oh ok. So the introduction of the internal resistance contributed to the difficulty of the topic?"

Mr. Tebogo: "Yes Sir."

Interviewer: "Ok. So it becomes difficult for you to teach or it becomes difficult for the learners to understand or both?"

Mr. Tebogo: "Both because as a teacher you once told them that the battery is just a chemical component, it doesn't have resistance. But all of a sudden now you are saying it's having resistance.

Interviewer: "So the problem now you need to change that understanding that we instilled in them."

Mr. Tebogo: "Yes. In them."

Interviewer: "Oh, by the way. You are the one who is teaching Grade 10 and 11 Physical Science?"

Mr. Tebogo: "Yes of course Sir."

Interviewer: "So you taught that the voltage supplied by the battery is this much in Grade 10 and also in 11. So when you go to Grade 12 you now say there is an internal resistance. So now that makes it difficult."

Mr. Tebogo: "Yes. It makes it difficult."

Interviewer: "Anything else other than that?"

Mr. Tebogo: "The other part is when you are trying to provoke the question. Let me just say, if maybe we switch S1, then what happen to the volt meter reading of the internal resistance or of the one resistor in the external circuit, it also puzzles thems a lot."

Interviewer: "No. Thank you very much Mr. Tebogo. Ehrr. Tell me, what are you going to teach today?"

Mr. Tebogo: “Today, I am going to teach electrical circuit.”

Interviewer: “Electrical circuit. No. Thank you very much. Ehrr… What resources do you have in your classroom that will help you to teach the topic?”

Mr. Tebogo: “I’m going to have the Caps document with me, the smart board, the textbook and also I’ll conduct some experiments as I continue with my lesson.”

Interviewer: “Oh you are going to use those to assist you to teach the topic. Thank you very much Mr. Tebogo. What is your opinion on the general performance in Physical Sciences?

Mr. Tebogo: “Ehrr... My opinion is that learners they tend to perform poorly in Physical Sciences due to the mindset they brought into class about this subject.”

Interviewer: “So they have a certain attitude and that attitude influences their……”

Mr. Tebogo: “Their understanding and comprehending of the subject matter.”

Interviewer: “Oh. Thank you very much. Ehrr… What is the socio-economic background of the learners in your school here and in particular learners in your class?”

Mr. Tebogo: “At one stage I used to ask my learners if they are studying at home and learners they bring different issues such as, at one point they said the environment at home is not conducive for them to study.”

Interviewer: “Oh ok.”

Mr. Tebogo: “Maybe that is one socio-economic that may also contribute.”

Interviewer: “Oh alright. No, thank you very much. Ehrr.. How long is your period and how many are you going to have today?”

Mr. Tebogo: “Usually it’s a 30 minute period but today I’m going to have twice of those.”

Interviewer: “Oh so it will make it an hour today?”

Mr. Tebogo: “Yes. It’s going to make it to be an hour, yes.”

Interviewer: “Ok thank you very much Mr. Tebogo. Ehrr… Which language or languages do your students speak?”

Mr. Tebogo: “My student, mostly they speak isiZulu and the others the speak seTswana.”

Interviewer: “Ok”

Mr. Tebogo: “So myself when I’m teaching, I use those language at some cases to make them understand.”

Interviewer: “So it’s only these 2 languages in terms of the learners’ ability… I’m saying the learners in your class its only isiZulu and seTswana or there are other learners maybe who at home they speak a different language but here at school they speak the 2 languages?”

Mr. Tebogo: “Yes of course there are those learners but just because their language is not served in our school, they don’t have that opportunity to speak it at school.”

Interviewer: “Oh ok. Thank you very much.”

Mr. Tebogo: “Like Tsonga and Venda. Some of them they speak those languages at home but here at school those languages are not offered.”

Interviewer: “Ok. Thank you very much. Ehrr.. What is your classroom size in most cases?”

Mr. Tebogo: “In my piece its 10 by 10 metres.”

Interviewer: “Like the number of learners?”

Mr. Tebogo: “Oh! The number of learners. In my lot of class they are 34 learners.”

Interviewer: “34 learners. And you only have one Grade 12?”

Mr. Tebogo: “Yes I only have one Grade 12 class.”

Interviewer: “And then, what is your view on the progress learners?”

Mr. Tebogo: “My view about progress learners is that some of the progress learners in my class have improved because they did well in the mid-year examination. But there are those who have less self-esteem about themselves. So they are the ones that are worrying me a lot those ones. But the others they are doing well.”

Interviewer: “So in other words is that do you have progress learners in your class?”

Mr. Tebogo: “Yes I do have progress learners in my class.”

Interviewer: “Out of the 34, how many progress learners do you have?”

Mr. Tebogo: “Out of the 34, I have 10 progress learners.”

Interviewer: “Oh from the 34 you have 10 progress learners.”

Mr. Tebogo: “Yes.”

Interviewer: “Ok, thank you very much Mr. Tebogo, we will go to student understanding. Ehrr.. what prior knowledge do learners need, to learn electric circuit better in Grade 12?”

Mr. Tebogo: “The prior learning you must bring to class when they start to provoke or when the electrical circuits are starting to be treated. They must bring the behavior of the resistances that are connected in series and those that are connecting in parallel. Their properties, their behavior. Then if they first master those, then is becomes much easier for them to comprehend the topic.”

Interviewer: “Oh ok. N0. Thank you very much. Do you know of any misconceptions that learners might have? If ‘yes’ how do you correct them?”

Mr. Tebogo: “At one stage I saw my learners, there was a combination of a series connection and the parallel connection. So my learner failed to combine the 2 that are in the series. Then he treated the one that is in series with the one that is in parallel as if they are in parallel. He was not aware of that, that is the combination of the 2 connections type of resistors.”

Interviewer: “And do you think this is because they were taught in the previous grade?”

Mr. Tebogo: “Yes. Yes. It’s a contributing factor as well that was being taught in the previous grade, because in the previous grade, usually it was only one type of connection of resistors.”

Interviewer: “Oh, then how do you, when you see that as a misconception, how do you best correct it?”

Mr. Tebogo: “I best correct it by going back to the definition of series connection to say how do you see the resistors as they are connected in series? To say, if there’s only one part for the current to flow from one resistor to the other, that is going to be a series connection of resistors. But if there’s an alternative part, is becomes the parallel connection.”

Interviewer: “Oh ok. Thank you very much. Are your learners interested to learn Physical Sciences?”

Mr. Tebogo: “Yes. I have good learners who interested in learning Physical Sciences because if I have set myself maybe for one day or missed their actual class for one day, they come and enquire to myself to say why were you not inside. That shows me that they are much interested in learning and studying Physical Science.”

Interviewer: “Ok. Thank you very much. Do you have learners doing Physical Science and Mathematical Literacy?”

Mr. Tebogo: “No. In my case, no. All of them they are doing pure Maths and Physics.”

Interviewer: “Oh they are doing pure Mathematics. Thank you very much. If we can go to the next page Mr. Tebogo. Let’s consider the… this one is based on the content knowledge. Let us consider the diagram below while answering these questions. Ehrr… Here we have a circuit diagram with the EMF of 15V. We also have the voltmeter reading of 12,9V and we also have an unknown resistance according to this diagram. We have a 4 Ohm and a 5 Ohm resistor together with R1 and an Ampere reading of 1.5 Amperes. How do you explain the difference between series and parallel connection?”

Mr. Tebogo: "I usually tell my learners that, in a series connection, it's when the resistors are connected one after the other. And there's only one path for the current to flow. There's no alternative part. Which means there's no branching of the current. But once there's a branching, it becomes the parallel connection of the resistors."

Interviewer: "So if you were to explain in terms of parallel connection you would say that, a parallel connection there is an alternative branch for the current to flow. Whereas, in series there is only one path for the current to flow?"

Mr. Tebogo: "Yes."

Interviewer: "Oh ok. Thank you very much Mr. Tebogo. What would you say to a learner, considering this diagram of course, who say when the switch S is open, the voltmeter reading is 12,9 volts?"

Mr. Tebogo: "I would have corrected the learner because if the switch S is open, which means that the voltmeter V is going to read the EMF. And the EMF in this case is 15 volts. So if switch S is open its going to read the EMF."

Interviewer: "Thank you very much Mr. Tebogo. What would you say to a learner who says when the switch is closed, the 4 ohm resistor will receive the same current as the 5 ohm resistor?"

Mr. Tebogo: "I would have said to the learner, the learner is quite correct. Because those ones they are connected in series. So the resistors in a connected series they are known as the potential difference dividers but the current stays the same."

Interviewer: "Ok. Thank you very much. So what would you say to a learner who say resistor R receives the potential difference of 15 volts?"

Mr. Tebogo: "I would have corrected the learner because 15 volts is an EMF which means, it's the amount of potential difference that the battery has before it start to operate. But once switch S is connected it drops to

	12.9 volts. Then that 12.9 volts is going to be the one that is going to be flowing in a series combination and the parallel combination.”
Interviewer:	“Oh ok. No. Thank you very much. What would you say now to a learner who would say… Let’s just not… It’s number 6… it’s not about the learners. If you look at the diagram, both the potential difference and EMF are measured in volts, what is the difference between the 2?”
Mr. Tebogo:	“All of them they are just amount of energy needed to move the charge. But the difference between the 2 is just that the EMF is the maximum potential difference that the battery has before it starts to operate in the circuit. But once it starts operating it drops. That amount that it’s going to drop with, if it drops with 0.1 volts, that is going to be said as the loss volt. Which means it’s the amount of energy that is needed to move the charge within the battery. So the remaining one is going to move towards the external circuit.”
Interviewer:	“What causes the lost in voltage in your view?”
Mr. Tebogo:	“It’s the amount of energy that must be used by the battery to move the charge within the battery.”
Interviewer:	“Within the battery. Ok no. Thanks very much. Let us go to the next 2 sections Mr. Tebogo. We are moving very fast, I like the pace. Ehrr, Section B. Instructional Strategies. The following are broad teaching strategies that discover activity driven enquiry and conceptual change. From these, tell me the ones you know and briefly talk about them. Which one do you know among those?”
Mr. Tebogo:	“Ehrr… Didactics, I can say, is the one that I know because it’s learning orientated. And it’s followed by Discovery of course. Because Discovery it’s when you have to read, you have to research. You have to find things on yourself. But didactics it’s what we are dealing with mostly in class to learners. So enquiry is when now you have to go an extra mile of your understanding about a certain concept. So that is my shallow understanding about ehrr….”

Interviewer: "Ok, thank you. Thank you very much Mr. Tebogo. What is your view on the use of lecturer method as a teaching strategy in Science?"

Mr. Tebogo: "At one stage lecturer method helps because it makes learning to be learner orientated either than being teacher orientated. But at one stage you must as a teacher do a follow up to say, has the learner abled to understand a concept. You must not just lecture and leave it as it is, you must also do the follow up. But lecturer method is also advisable because it makes learners to commit themselves in their learning."

Interviewer: "Thank you very much Mr. Tebogo. Ehrr… Representation includes among others, examples, modules, analogues. Briefly talk about them. Which one do you use and how would you use it? Among those."

Mr. Tebogo: "Of course, I use models because you must model the electrical circuit before you present it to learners. In my case, I model the electrical circuit when I'm doing the practical part of electrical circuit. Then we analyze from there to say, if this is the kind of connection, this is what's going to follow. This is what we expect just before we conduct an experiment. Which means that we are having that theoretical part before we conduct our experiment. So we analyze it on that sense."

Interviewer: "Oh, thank you very much Mr. Tebogo. Activities among others include demonstrations, simulation, investigation and experiments. Can you kindly talk about these and which one do you usually use in the lesson?"

Mr. Tebogo: "I use, I like the one of simultations and investigations because its ones that is mostly makes learners to find an interest in the lesson. If you assimulate to learners, for example, if you are having, of course your classroom is going to be edified then you start to explain to them to say, the reason why if one light bulb in the classroom blows off, the other one it remains with electricity. Which means that is the reason it is the type of connection which is parallel connection because a parallel connection, if one light bulb dies the other ones remains alive. So that I think is a good demonstration that I use to conduct in class."

Interviewer: "Ah thank you very much Sir. And now let's go to Section C, the interaction and discourse. When you are presenting a lesson, do you ask questions to evaluate or develop a question?"

Mr. Tebogo: "I usually ask to evaluate, to say the knowledge that I presented to them, have they able to grab it and to check their level of presentation. So I do ask questions during my lesson."

Interviewer: "To evaluate?"

Mr. Tebogo: "Yes. To evaluate."

Interviewer: "Oh alright, thank you very much. Given this type of commutative approaches, interactive authoritative, non-interactive authoritative, interactive dialogic and non-interactive dialogic, which one do you think you use?"

Mr. Tebogo: "I prefer one of interactive dialogic because it's when the learners are having the opportunity to ask questions back to me when I ask questions toward them. So they have that opportunity to ask questions and they become free in class and it tend to develop interest with the lesson that I'm presenting to them. Even on after schooling hours, I advise them to come and ask questions on the lesson that we have treated in class."

Interviewer: "Oh ok. Thank you very much. Which pattern of discourse do you think you use under authoritative dialogic and reflective?"

Mr. Tebogo: "I think the pattern that I use to ask is the one of dialogic and reflective to them as well."

Interviewer: "Ok. Alright, no. Thank you. And then which pattern of discourse initiation, response and feedback or you use initiation, response, feedback, response and feedback do you use in your classroom?"

Mr. Tebogo: "I use the initiation, response and feedback, response, feedback in my classroom because I must also ensure that the learners have understood the certain concept and I must find out from them to see they have abled to understand the concept well or there are some loopholes that I still have to fill. So in that sense it helps me because, if there's a loophole or if I sense that the learners, from their response, that there's a loophole, I have that opportunity to go back and try to level that."

Interviewer: "Thank you. Thanks a lot Mnr. Thanks a lot. Ehrr… Let's go to the last section which is Section C. This one it is based on accountability. How does the need to cover electric circuit in 4 hours shape your teaching?"

Mr. Tebogo: "Is becomes much strenuous to me because I have to try to sum all these things in 4 hours while it's not enough. (cellphone rings) It's going to require an extra time for me to stress on some of the points in electrical circuit."

Interviewer: "So in order, because you are now chasing time, what alternative means do you come up with in order to ensure that the content is covered?"

Mr. Tebogo: "I go for an extra mile conducting extra classes. Morning classes, afternoon classes and even weekend classes because I want to have assurance that the learners have able and have understood what I have been teaching to them."

Interviewer: "So, generally, you are saying 4 hours is not enough to teach the whole electric circuit topic."

Mr. Tebogo: "Yes. Is not enough unless is a hit and run. But at the end of the day is come back and harmed you."

Interviewer: "Oh ok. Thank you very much. Do you comply with weekly informal tests? If 'yes', how does that shape your teaching as well?"

Mr. Tebogo: "Yes, I comply with weekly informal tests and I do it just to evaluate my learners but at the same time, at one stage, it comes while I haven't covered that topic. But I don't stress, I give them because I want to see their response to that particular evaluation test informal test because is not recorded."

Interviewer: "So so so because they would be filling a topic that they did not, you have not yet taught, maybe a section of an electric circuit that you have not yet taught, does that have any effect on them in understanding the topic in the future? Maybe say for an example, they answer something that you have not taught, so when you go and teach that topic, does it improve or discourage them to…."

Mr. Tebogo: "It encourages them because now they become curious to know about that particular topic that they didn't do well in the test. It enhances their level of understanding because they have that ability, they have that eager to enquire and find more about the topic to say why we didn't got this wrong in a test."

Interviewer: "Thanks, thanks a lot Mnr. When you teach your learners, do you teach them to understand or do you teach them for examinations? Any answer you choose or take please explain it a bit further."

Mr. Tebogo: "For me because now our teaching is much on examination orientated, I teach them to pass the examination. Just because if I can teach them to understand I won't able to finish on time. So I teach them to able to answer an examination question paper. Then is end there."

Interviewer: "No understanding needed as long as they are able to respond to the question paper?"

Mr. Tebogo: "To say 'the resistor is made up of this material' I don't go as far as that point. I just say the resistor is a component that stops the flow of that current."

Interviewer: "So when you are teaching, you tell them, infact you just tell them or you direct them to say these are the typical exam questions you must know. And when this question come, this how you must respond."

Mr. Tebogo: "Yes of course Sir."

Interviews: "Oh ok, thank you very much. What would you say to a subject advisor who says you are left behind with the annual teaching plans, the work schedule?"

Mr. Tebogo: "Usually, that happens to me but I tend to tell my subject advisor that I'm going to have, make time, extra time to try and cover that work. But their mentality is always on completing the work schedule without any understanding. Without perceiving that you as a teacher you have saw a need for you to go back and stress more on that particular point which end up putting you behind the work schedule."

Interviewer: "Thank you very much. This question I think it's irrelevant but it's only fair that we answer it. Do you progress learners in your class who fail Physical Science in Grade 11? If 'yes' how do you ensure that they close the content gap or the prior knowledge?"

Mr. Tebogo: "Yes I do have those kind of learners who have progressed from Grade 11 who have failed Physical Sciences. But, as now we are preparing for the examination, I have started a initiative to say now I must divide them and they must not feel offensed but is for their own good. Those that are doing well, I give them extra work to continue with work. But those that are struggling, I sit down with them and I help them where I can. I think that one is going to help them to improve their performance in the oncoming examination."

Interviewer: "The Tshwane West District has adopted #45 targeting simple questions in the question paper. Are you also subscribing to that #45?"

Mr. Tebogo: "Yes Yes Sir."

Interviewer: "How do you implement it?"

Mr. Tebogo: "The #45 is saying we must concentrate only on simple questions. So I have also implemented it in my classroom. Those learners who are struggling, I don't go to difficult topics. But I go to those topics that I have assurance that they are going to get them correct."

Interviewer: “Now I see here in #45 adopted by the district that the electric circuit is only given marks.”

Mr. Tebogo: “Yes.”

Interviewer: “How is your… what is your take on that?”

Mr. Tebogo: “Ehrr.. Eish.. 3 marks its to little but we must follow the lead of the seniors. We must not defy their word.”

Interviewer: “So it’s all about complying to the senior. Thank you very much Mr. Tebogo. Now do you teach progress learners with high flyers using the same strategy?”

Mr. Tebogo: “No. Now I have started to separate them because the high flyers if they are being combined with the progress learners, they feel as being their time being wasted. And the progress learners when a certain question is being answered, they take time to finish the activity. But the high flyers they finish quickly with the activity. So now the best option I said I’m going to separate them they must not feel offended but they must take it as the aid that’s going to help them.”

Interviewer: “Oh! To help them pass the examination. Ok, how often do you assess your learners?”

Mr. Tebogo: “Weekly. I do it on a weekly basis because the district have been sending us weekly tests.”

Interviewer: “So is the assessment for high flyers or average learners the same as the one of the progress learners?”

Mr. Tebogo: “The assessment is the same.”

Interviewer: “But the teaching is different?”

Mr. Tebogo: “The teaching is different. The teaching is done to pull the progress learners to that level of passing.”

Interviewer: “So after assessing them on those weekly basis, how do you assist learners maybe who failed that assessment?”

Mr. Tebogo: "I always take them when we are doing the corrections because we always swap the question papers. Then those that have did poorly on that particular test I took an extra mile with them. I further separated them, then after I explain to them with the very same question while the others are doing other questions but of the similar context. Then in that case they tend to understand that particular concept."

Interviewer: "One last question Mr. Tebogo, I see now that there is a new word in the education sector more especially when it comes to Tshwane West District. It's called intervention. What is your general understanding of the word?"

Mr. Tebogo: "Man, I have a good understanding of the word 'intervention'. But at one stage you feel like there's a failing out from the managerial table maybe of the school or parental support from home. Because at some stage you find out that if you have to do that intervention program, some of the learners they tend to absent themselves. If you ask them, they say, maybe they have attended a funeral somewhere. Maybe they went to do a certain home chores. This becomes difficult for the intervention to go smoothly. But it's a good initiative."

Interviewer: "Thank you very much Mr. Tebogo. I appreciate that once more. Then I will be joining you to your class today. Thank you very much."

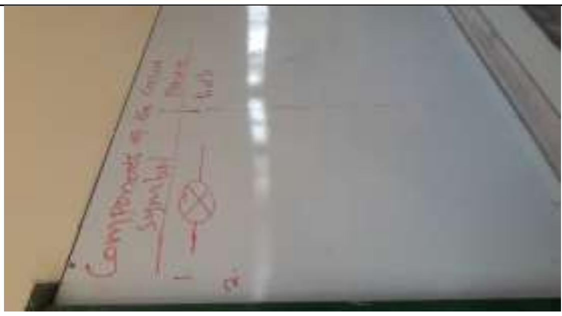
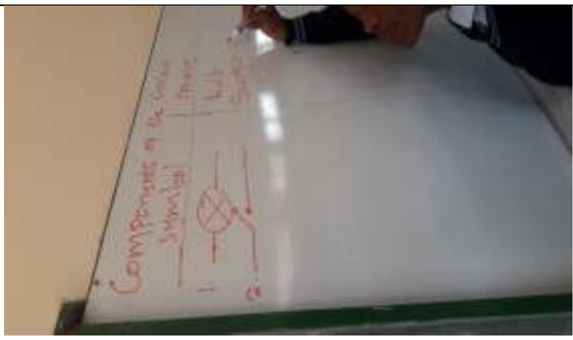
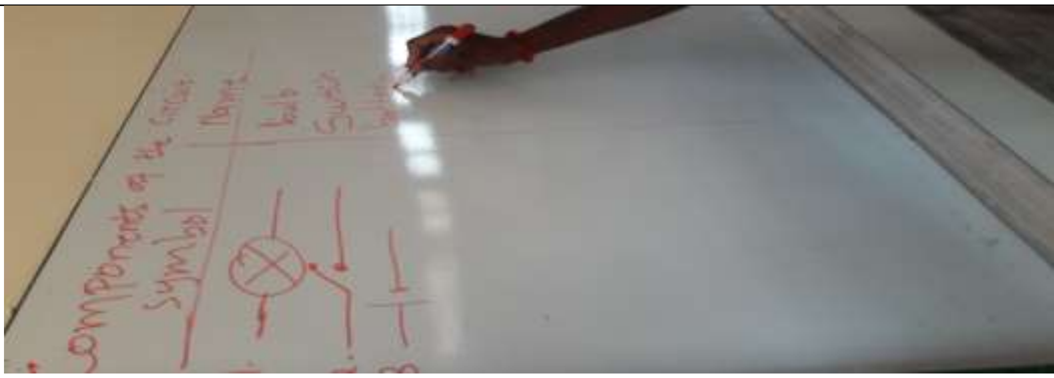
Mr. Tebogo: "Thank you Sir."

APPENDIX L:
OBSERVATION PROTOCOL CASE 1

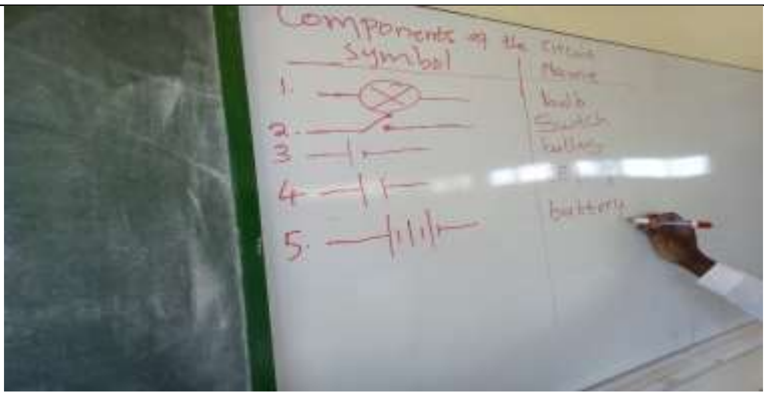
Line	Description
1.	There were thirty-three learners in the classroom. The classroom was clean
2.	with tables well arranged. There was a smartboard and whiteboard in the
3.	front of the classroom. The teacher entered the class and greeted the
4.	learners" *Good morning good people"* and the learners responded "*Good*
5.	*morning sir*".

The teacher started the lesson by explaining the atom. He explained that an atom has protons and electrons. He sketched the model of an atom on the board.

He explained that in an atom if there are equal number of protons and electrons, then the atom is neutral. And if there are more electrons than protons, the atom is negatively charged. Furthermore, if there are more protons than electrons then the atom is positively charged. The teacher pointed out that charges can either be positive or negative and positive charges are called cations while negative charges are unions. The teacher reminded the learners that in grade 10 they looked at metals and learned about delocalised electrons (charges that move from one point to the other) we look at electric circuits while charges the not flowing we look at electrostatics. The teacher said “we are surrounded by circuits” and he gave an example that MR R (researcher) is using an audio-type there it has a battery meaning it has circuits which is the chapter for today. He further said “I normally make use of my phone” it has a battery meaning we have circuits in it because the battery delivers current to different components of the phone? He made another example and said ‘’at home we have electric circuits where we connect stoves and light bulbs, those are connections within a circuit and for that to happen we need a source”. He said at homes we are supplied by Eskom but for his cell phone he have a battery. He further said to start with electric circuits in grade 12 we look at what we did in grade 10 and 11. He explained that the concepts of electric circuits are very important. He started by writing “components of the circuit” on the board. He told them that he remembers one of the electric components and its symbol, he mentioned a light bulb. He sketched the symbol of the light bulb on the board and name it on the other column of the table(No1). The table

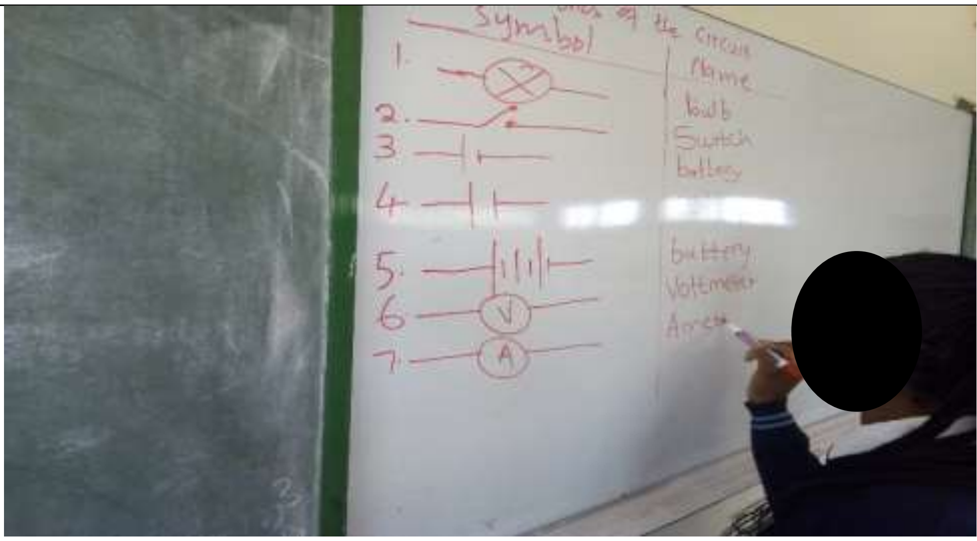
34.	had two columns, symbol and names. No1
35.	
36.	He then asked learners to sketch and name other components. Learners
37.	raised their hands and the teacher pointed one learner and the learner
38.	named a switch and she stood up and sketch the symbol and name on the
39.	board. No 2
40.	
41.	The teacher asked the learners if the symbol and name are correct and
42.	learners said “yes” he further asked whether the symbol is for an open or a
43.	closed switch? The learner who sketch the symbol said it is for an open
44.	switch. He said that is correct, very good.
45.	He asked them (leaners) to name other components. Another learner said a
46.	battery. The teacher asked him to sketch the battery on the board. The
47.	learner stood up and sketch the symbol of a battery. No 3
48.	
49.	The teacher asked if he is correct. Some learners said yes and some said no.
50.	The teacher asked learners who said no to explain why they said No? One of

learners said in grade 10 you taught us that a battery has two or more cells while a cell is only one. The teacher asked the learner to sketch the symbols of what he is saying. He sketched two symbol and wrote cell (No 4) and on the other one he wrote a battery (No 5)



The teacher asked another learner MR L (calling a learner by his name) is this correct? He said yes sir, respond the learner. The teacher agreed that is correct.

He asked them the meaning of the short and long lines in a battery and a cell. Learners raised their hands and the teacher pointed at one learners and said tell us Ms M(calling a learner by her name), she said the long one represent the positive terminal and he short represents the negative terminal. The teacher responded and said correct. Another learner stood up and sketch a voltmeter (No 6) and an ammeter (No 7)



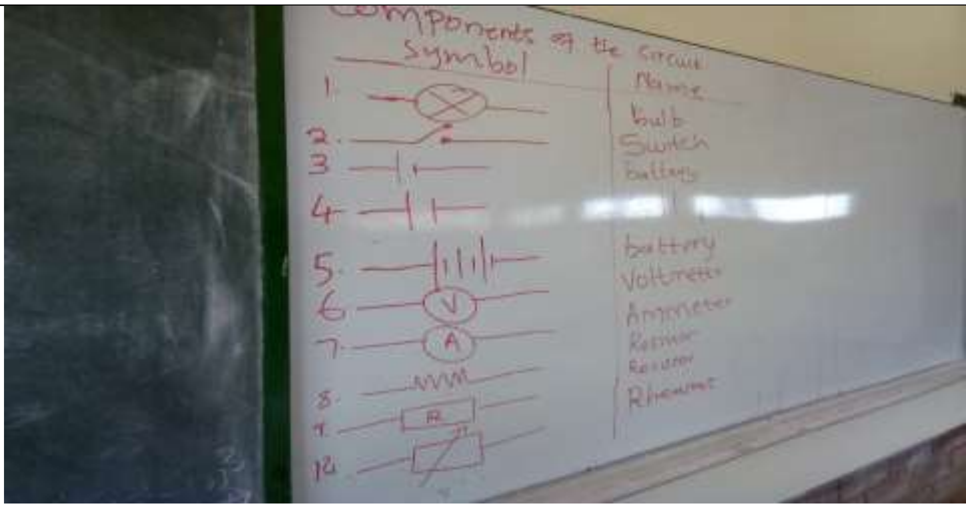
Learners said (chorusing) yes, yes, yes, while clapping their hands. The teacher appraised the learner “excellent work”

The teacher then asked them if they are done naming the components. The learners said no. he pointed at one learner by calling her name which components is not mentioned Ms N. she said a resistor and she stood up and sketch the symbol(No 8)

Another learner raised a hand said “sir that is not a resistor”. The teacher said come sketch a resistor Ms O (calling learner name) she sketch her version of a resistor(No 9)

The teacher asked the class “who is correct between the two” learners had different views with other agreeing with Ms N and others Ms O but failing to give reasons why one is correct and the other is incorrect. The teacher concluded by saying they are both correct. They are “alternative” symbols both representing resistor.

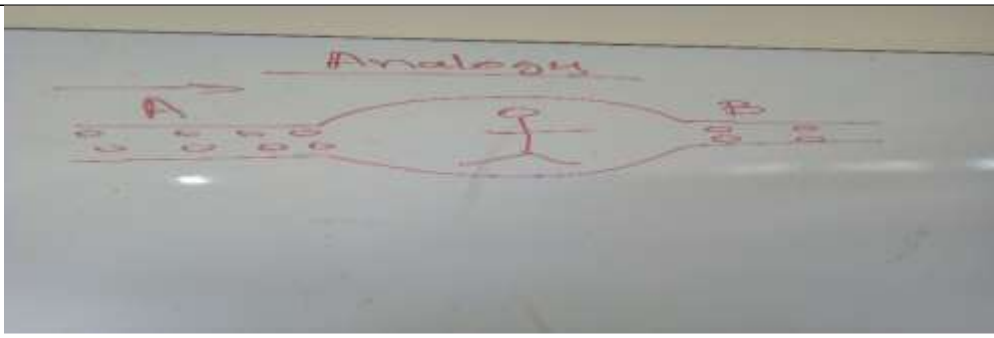
Are we done? Asked the teacher. The learners said we are only left with the wires sir, but he did not ask learners to sketch the symbol and the name of the wire neither did her comment on the answer. Anything else? Asked the teacher. The learners said no sir. The teacher wrote the symbol(No 10)



and ask learners if they remember the symbol. One learner said is another alternative for resistor. The teacher asked the class, is she correct? No learner responded. The teacher said “this is a rheostat”. He explained that it looks like a resistor but it has an arrow. This arrow shows that it can vary the resistance.

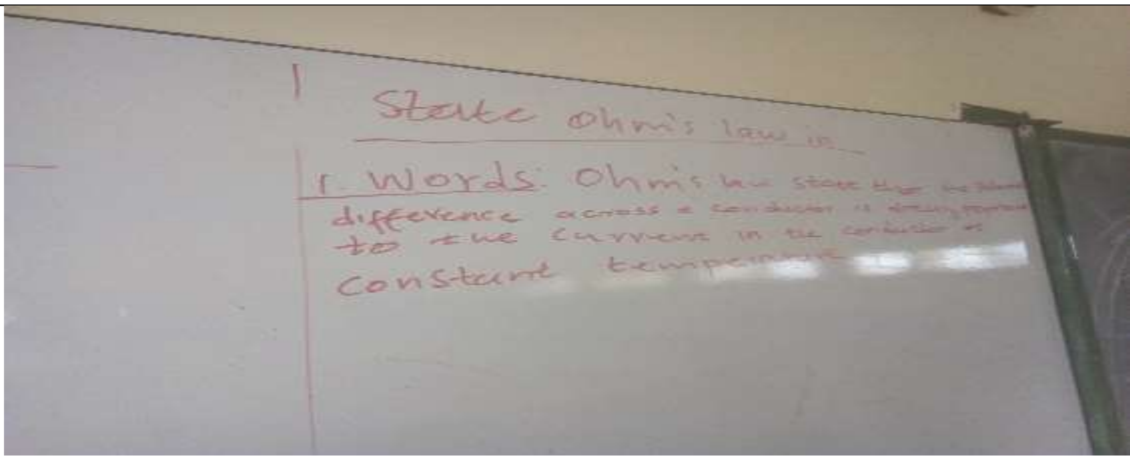
He then said that there are three main things which we talk about when we look at electric circuits which are resistance said the teacher. Mr P tell us the other two, the learner (MR P) said current and voltage.

He started defining current as” the rate at which charges are transferred” while he wrote it at the white board. He explained that for electrons to pass from one point to the other it will take specific time interval. He defined resistance while writing on a board as “an opposition of charges/current to flow” here he made an analogy that explain the resistance.

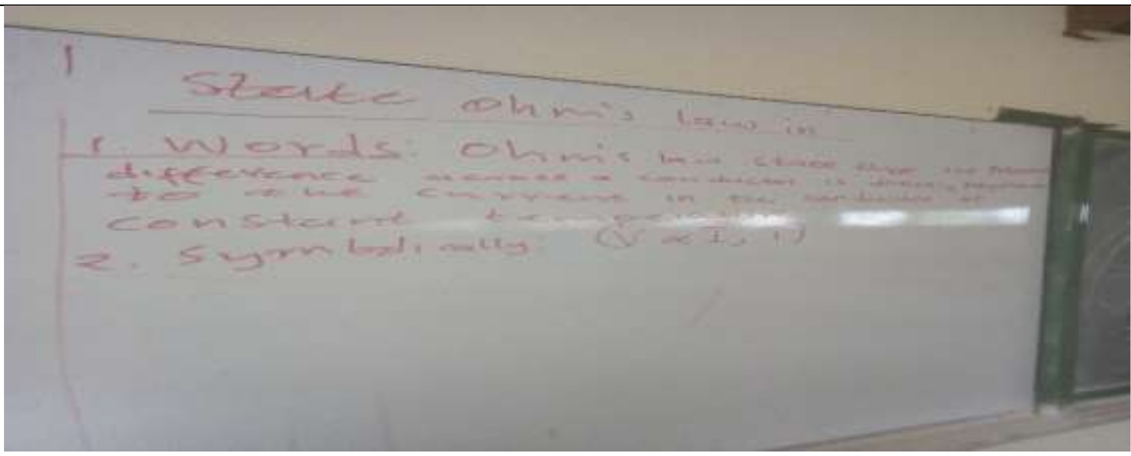
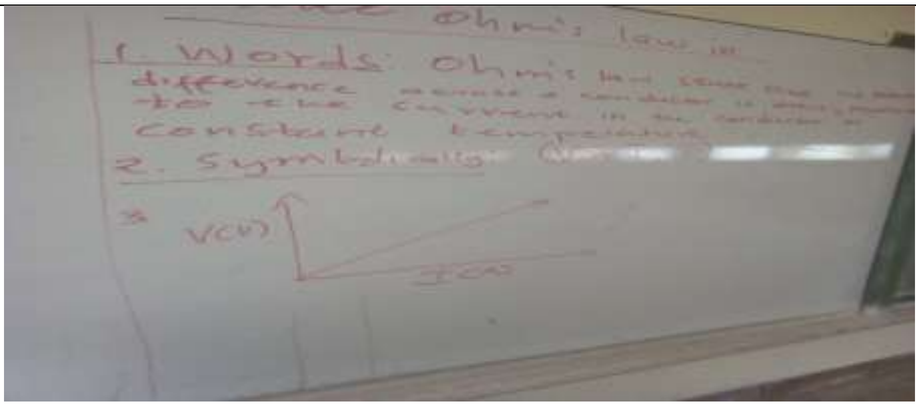


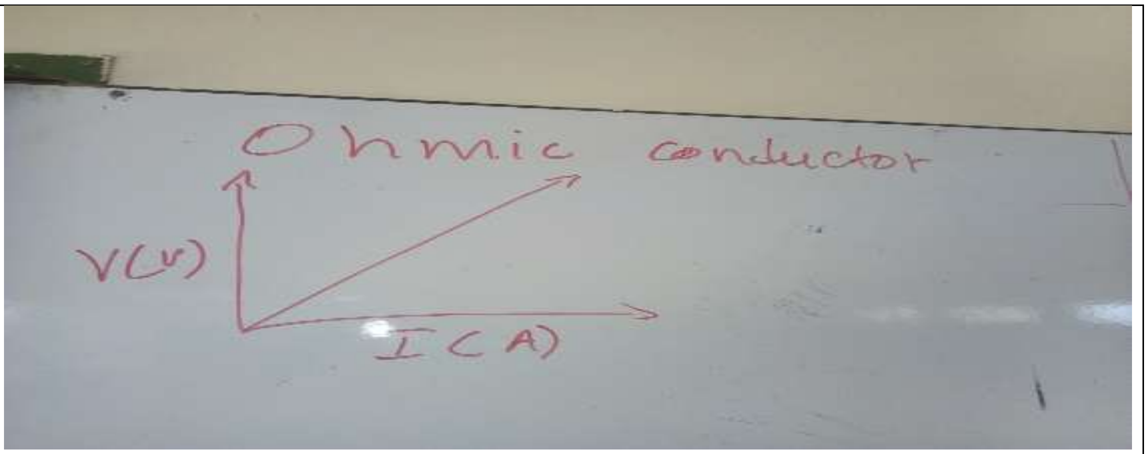
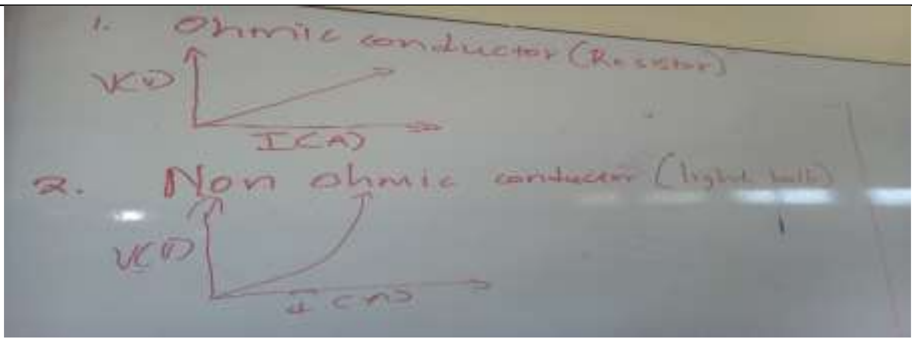
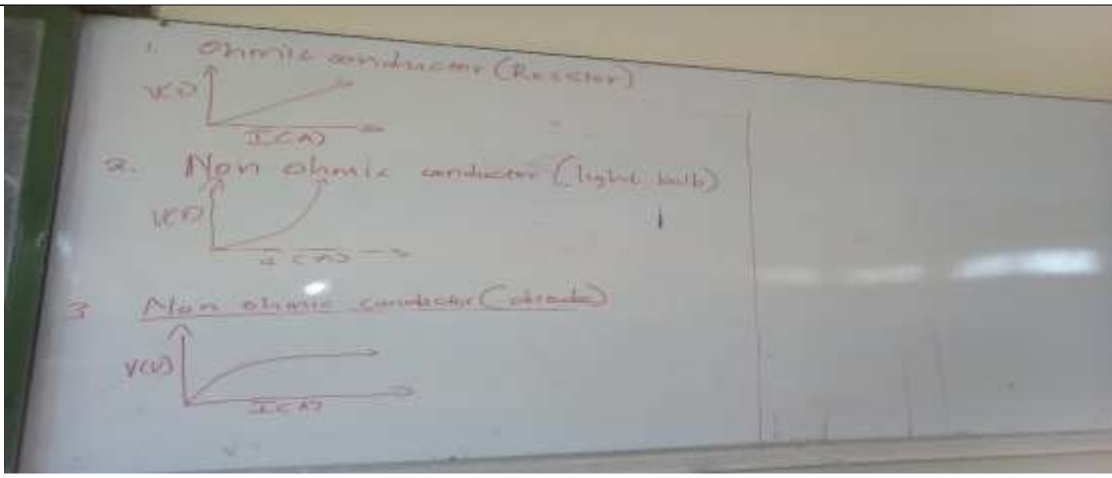
He said resistance can be referred to the analogy above, which has eight electrons in section A moving towards section B. The person standing in between acts as a resistor. In section B there are only four electrons. He said this means that the resistor(person) opposed the flow of four electrons. He highlighted that there is a high potential in section A and low potential in section B. He further explained that if the person standing in between was not there will not be a difference in potential between section A and section B. The presence of the person is what makes a difference and in electric circuits we call it potential difference. He said it is so because there is high potential in section A than in section B.

He then asked learners if they still remember the factors that affects the resistance. Three learners answered with one each of them saying” the temperature”, the thickness of the conductor and the type of material used. The teacher then said that there is a relationship between the current and potential difference and this relationship is explained in Ohm’s law. He ask learners to define Ohm’s law. Learners (chorusing) Ohm’s law states that the potential difference is directly proportional to current. The teacher ask learners to raise their hands. One learner stated and said “*the potential difference across a conductor is directly proportional to the current in the conductor”*. The teacher asked to class if she is correct or incorrect. The learners (chorusing) it is correct. The teacher said is not correct because there is no mention of temperature. He then stated the law while writing on the whiteboard as” the potential difference across a conductor is directly proportional to the current in the conductor at a constant temperature”. No 1



he further said you (learner) must be able to also state the law symbolically and graphically. Who can state it for us symbolically? A learner stood up and wrote on the board. No 2

129.	
130.	The teacher then asked the class if he is correct or income? The learners
131.	said he is correct. He also asked them to state the law graphically and Ms
132.	N(learner) stood up and she sketched (no 3). The learners slapped hands for
133.	her as she leaves the board.
134.	
135.	He said the graph V versus I is a straight line through the original. While
136.	explaining the graph he said that the greater the resistance(Ω), the smaller
137.	the current (A) and the greater the resistance, the greater the potential
138.	difference (V).
139.	The teacher the introduced Ohmic and Non-Ohmic conductors. He asked the
140.	learners if they know anything about the Ohmic and non Ohmic conductors.
141.	No learner raised a hand or responded. He then explained that Ohmic
142.	conductors obey Ohm"s law and make an example of a nichrome wire. He
143.	also sketched a graph of an Ohmic conductor.

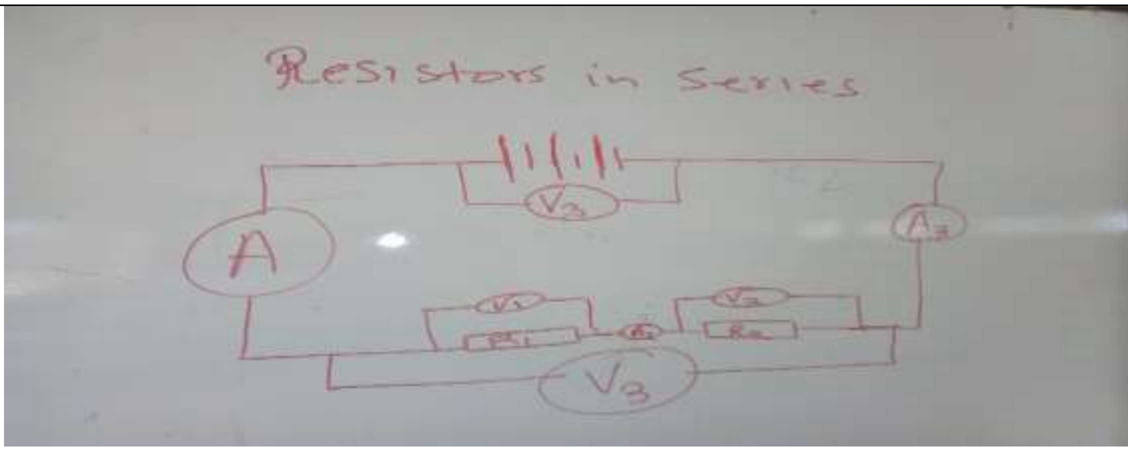
144.	
145.	He explained that the temperature remains constant in an Ohmic conductor.
146.	He also sketched the graph of a non-Ohmic conductor, fistly using a light
147.	bulb as an example. No 2
148.	
149.	Here he explained that the filament gets very hot with the rise in temperature,
150.	an increase in temperature mean the conductor does not obey ohm’s law.
151.	Lastly, he made an example of another non-Ohmic using a semiconductor
152.	diode as an example and explained that at first the current increases slowly,
153.	then faster, the resistance suddenly decreases as the current increase. He
154.	then sketched a graph to explain that relationship. No 3
155.	

The teacher concluded the lesson and ask learners to bring different colour pencils.

Day 2

The teacher settled the class and ask learner to take out the different colours pencil as requested the previous day. He said today we are going to do series and parallel connections and we will conclude by doing the series-parallel and parallel-series networks.

He wrote on the board “*resistors in series*” he also sketched a diagram



While referring to the diagram, he explained that a series connection is a connection that resistors connected receive the same current. He explained while pointing from A to A_3. He said that R_1would receive the same currentR_2 He wrote the equation on the board: $I_T = I_1 = I_2$,the teacher made an example that if the circuit supply 2A as the total current, R_1 will receive 2A and R_2 will also receive 2A. The teacher further said resistors in series connection are voltage dividers. Thus, $V_1 + V_2 = V_3$ while referring to the diagram on the board. He made an example that if the circuit supply a voltage of 6 volts (V), R_1 will receive a voltage different from R_2 provided the resistance of$R_1 \neq R_2$. He explained that the total will be given by the addiction of the two voltage through R_1 and R_2.while explaining the resistance in series the teacher indicated that to calculate the total resistance of any number of resistors connected in series, we use the equation :

$R_s = R_1 + R_2 + ...$

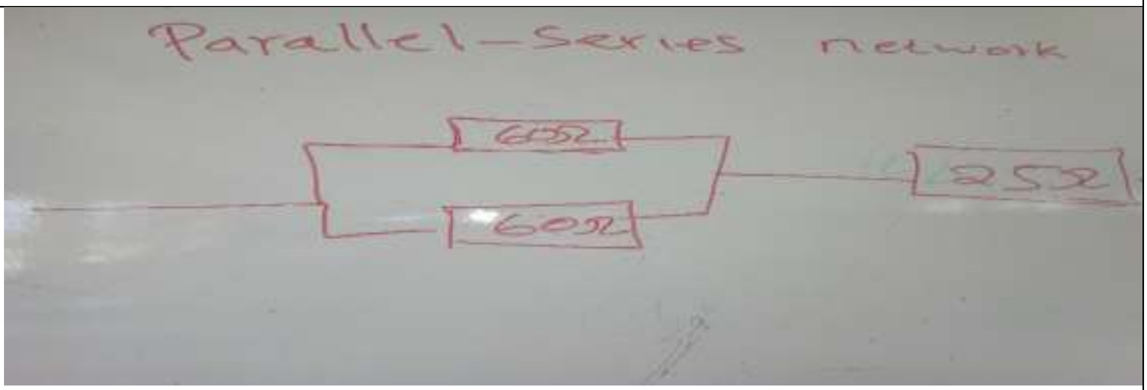
The teacher then wrote “resistors in parallel” on the board.

While also referring to the diagram, he explained to the learners that resistors in parallel connection as opposed to series are current dividers with $I = I_2 + I_3$ and $I_2 + I_3 = I_4$, he elaborated that it so because $I = I_4$.Here he also used an analogy of a pipe.

The pipe had three openings of different sizes in the middle and also joined to form one pipe in the end. In his analogy he explained that as the 5L liquid approaches the three openings, it is distributed according to the width of the opening. He also spoke about Kirchhoff’s current law and explain that the law deals with the conservation of charge entering and leaving a junction. He explained that the law implies that the current entering from C1 will be the same as the current leaving by C2 in the diagram (parallel connection). He said that the greater the opening the greater the liquid it draws but where the pipe converge the liquid drawn by each opening will be equal to 5 L. However, the teacher indicated that with electric circuits it is different because the greater the resistance, the smaller the current. It was because of the definition of resistance, the teacher said. He indicated while pointing from A that as the current flows it will split from C1 where R_1 will receive a current different from R_2 if the resistance in $R_1 \neq R_2$. While pointing at the diagram he showed that the voltage in any of the voltmeters will be equal. Be it in V_1 and/ or V_2 the reading will be the same. He also demonstrated using formulas how to calculate the total resistance in parallel using the equation:

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots\ldots.$$

The teacher then heighted to the learners that if they know the characteristics of both series and parallel connections then it will be easy for them to understand parallel-series networks and series-parallel networks, He sketched the below diagram on the board:



He asked the learners whether the diagram represent a parallel-series networks or series-parallel networks? One of the learners said it is both, some responded it is series-parallel and others said parallel-series networks. The teacher advised learners to look at the two resistors that are connected in the series and in parallel. He said the two connected in one setup will give them the name that come first. Learners did not respond. The teacher asks them while pointing at the diagram" what is the combination of 60Ω and 60Ω resistors?" Learners said parallel combination. He further asked "what is the combination of the 25Ω resistor with the 60Ω resistors, learners said series. He then asked the question again "is the diagram parallel-series networks or series-parallel networks?" learners raised their hands and the teacher pointed at one learner who said" it is parallel-series sir. Why? Asked the teacher. The learner responded and said "because the 60Ω resistors are connected in parallel and they are in series with the 25Ω resistor. The learner said you said we should look at the two that are connected in one setup first. he agreed that the circuit is parallel-series network. The teacher asked one of the learners to explain what will happen to the voltage in the circuit. The learner indicated that two 60Ω resistors will receive the same voltage. The teacher asked her why do they receive the same voltage, the learner said that it is because they are connected in parallel. The teacher asked another learner to explain what will happen to the current, the learner said it will not be the same. The teacher asked for a reason, the learner said that the 60Ω resistors are connected in parallel so the current is not the same in parallel. He further added that the sum of the 60Ω resistors with respect to current will be the same as the one in 25Ω resistor.

He asked them to explain how they will calculate the total resistance. Pointed one learner who said “just add 60Ω+60Ω+25Ω and get the total”. He asked her whether the three resistors are connected in series or in parallel. she said the two 60Ω resistors are connected in parallel and they are connected in series with the 25Ω. The teacher then asked her how resistance in parallel connection is calculated? The learner said we use” $\frac{1}{R_p}=\frac{1}{R_1}+\frac{1}{R_2}$ and he asked him how do they calculate the total in series? He said we use $R_s = R_1 + R_2$. One learner offered to assist, in his explanation he said we first calculate the total in resistance in parallel using the formula $\frac{1}{R_p}=\frac{1}{R_1}+\frac{1}{R_2}$ and get a value, then will have one resistor representing the two and we use the formula $R_s = R_1 + R_2$ and the value will be the total sir. The teacher asked other if he is correct. The learners said Yes! Yes! (chorusing). He asked the class to clap hands for him and learners clapped hands. He said that is excellent my boy, while he distributes the handouts for a homework

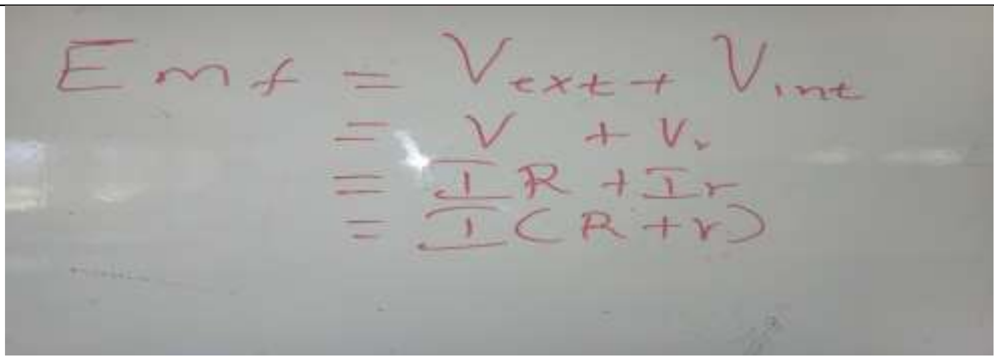
End of day 2

Day 3

The teacher introduced the topic while he writes it on the whiteboard” *internal resistance*”

The teacher explained to the learners that in grade 10 and 11, all electric circuit problems were simplified by ignoring the resistance of the battery. He further explained that a real battery has some resistance between the terminals, called internal resistance. He explained the two types of resistance namely: external resistance (R) is the total resistance of all components connected in the external circuit. He also referred it to as the load. He then defined internal resistance as the resistance that charges experience when they move from one point to another within the battery. The teacher then played a video via smartboard. The video shows the voltmeter reading of 1.05V while the switch is open but a reading of 1.03V was detected when the switch is closed.

After few minutes of playing the video, the teacher stopped the video and ask if learning have noticed the change on voltmeter reading. Learning answered and said yes. The teacher explained that it is because the internal resistance within the battery itself. He explained that the resistor within the battery use consume certain amount of energy and it have to be treated like any resistor in the circuit. (energy supplied by the battery= energy used by external resistors+ energy used by internal resistors.



The lesson ended.

APPENDIX M:
OBSERVATION PROTOCOL CASE 2

Teacher: “Before we start, we are all aware that, laitsi ke mang. Ke mo introducile. But now I’m going to start with giving you this example. We have a door neh?”

Learners: “Yes.”

Teacher: “And then you are all in here. Ko thella molilo at the back or there's a snake somewhere there. What will happen? We are all going to run through the….”

Learners: “Door.”

Teacher: “Trying to go out, neh?”

Learners: “Yes.”

Teacher: “Ok. But we cannot all fit in the…”

Learners: “Door.”

Teacher: “Ok. So imagine if we want to try to fit in the door, all of us ritswe. Are we there? What’s gonna happen is that other people won’t be able to go…”

Learners: “Out.”

Teacher: “Ok, I think 2 classes from this block there’s a hall, akere? That hall it’s even bigger. Same people run. What will happen? We will all pass there. Akere?”

Learners: “Yes.”

Teacher: “Ok. So that’s how I introduce my lesson today. (Writing on the chalkboard) Electric Circuit. Whatever the analogy I just take you through, just put it in your mind. You will understand as we move on, neh?”

Learners: “Yes.”

Teacher: “In a few seconds, I will just take you a little bit back because you did this in Grade 10 and all that. I will be concentrating in the following: (Writing on the board) you must know how to define Ohm’s law. After defining Ohm's law, that’s number 1, it’s very important. Number 2, you must know your connections in that Electric Circuit. Are we clear? You are going to differentiate our connection in the following which is (Writing on board) Series, Parallel and both, akere?”

Learners: “Yes.”

Teacher: “Number 1 you will have to study Series Connection. Number 2 Parallel Connection and number will be both in 1, akere?”

Learners: “Yes.”

Teacher: “Ok. I am not going to define this law (underlining Ohm's Law on the board). I know you people are going to define this law because we have to interact. Let’s start, neh? I will just write the formula of Ohm's Law which is R = V/I (class in chorus). Can someone give is the definition please. Re nyaka babasaitsing. (Pointing at one of the learners). Bua ousi Lolo. Ok, babaitsing ke. (Learners burst in laughter).”

Learner: “The initial difference across a resistor, the magnitude…..”

Teacher: “La motlwa o e libetse. She's writing tomorrow, the possibility of that definition coming in the exams, it’s 99% chances. (Points at another learner).”

Learner: “The potential difference is directly proportional to the current.”

Teacher: “But you are missing something. There’s something that is missing.”

Learner: “At a constant temperature.”

Teacher: (writes answer on chalk board) “Temperature neh? Now we go back to that analogy, the one that we started with. La e gopola neh? Why we won’t be able to go out monyakong ola?”

Learners: “Komonyane.”

Teacher: “Komonyane?! And ha homonyane, what happens? The door doesn’t allow us, neh?”

Learners: “Yes.”

Teacher: “Yes. It resists us. (Writing on the board) The door does what?”

Learners: (in chorus) “It resists us.”

Teacher: “It’s very important on Ohm's Law because that’s what we are going to be talking about, resistors in a connection. Because these resistors, ke tsona tse o reng, they will make us understand this, the type of connection. Now the smaller door doesn’t cater many people to go out from the door. And the bigger door allows many people to pass. Oh! Let’s talk about people as charges (writes on board), akere? Now, you are going to have a circuit. In a circuit, charges are doing what?”

Learners: “Moving."

Teacher: “The rate at which these charges are moving is called current. Are we here?”

Learners: “Yes.”

Teacher: “Amperes is correct because Amperes are the unit of current. Now because these charges are moving in a circuit, let me just draw a simple circuit. Now charges must move, akere? When these charges are moving in a circuit, they will prefer to go to an easy path. The charges will try to move to the easy path. Why easy path? Because there is no resistors. If something is happening at the back, you would rather go out using the window rather than where many people are going. Are we clear, neh?

Learners: “Yes”

Teacher: “The charges will prefer an easy path where there’s less resistance so that they can pass easily. Ke a tshepa raotlwana?”

Learners: “Yes.”

Teacher: "Thank you. Now as these charges are going to move, there is different types of connection, akere? Ok, let's come out with another example, laitsi koTembisa? Those who know Tembisa or Alexandra, there's a type of connection that is happening there, izinyoka. So ya, because of izinyoka, pleke ela etshwereng the main power. Now when we are busy connecting from that house, to the other, what happens to the brightness of the light?"

Learners: "It becomes dimmer."

Teacher: "It becomes dimmer and dimmer. Why does it become dimmer? It is because of the type of connection. Ok, that type of connection, let's give it a name. Now, type of connection. Very important part now of you understanding electric circuit that by the time I'm going to finish this explanation, everything will be done at last. (Writes on board) Series Connection. We said something becomes dimmer and dimmer. Now when we represent a Series Connection, this is what, this is our type of (sketches a circuit on board) connection, akere? Ehrr... These are my resistors. Oh, kana it is caps, Eish! (Makes correction on sketch). I forgot, I'm sorry. In caps, according to caps document, I must make rectangles, neh? Those are my resistors. This is Resistor 1, this is Resistor 2 and that one is Resistor 3. Now because you have said that the light becomes dimmer and dimmer, we are going to make a conclusion that says, Vt, which is the potential difference at the house that is having the main power source, will be equals to the sum of those potential difference from the different houses. (Writes $Vt=V^1+V^2+V^3$ on board). Now but when I make this, we can make a conclusion to say, a potential difference across in series connection it is divided according to the proportion of the resistors. I start again. Because the bright becomes dimmer and dimmer as we move far away, we make a conclusion that says, according to this (Pointing at equation on board), the potential difference across a Series Connection, it is divided according to the proportion of the resistors. Meaning the Resistor 1 will have a greater potential difference than Resistor 2 and Resistor 3 because you have said, according to

Tembisa's connection, the light becomes dimmer and dimmer as we move far. Gona gore, when this potential difference is being lost, the bulbs are going to switch from far as we come closer to Resistor 1. Closer to the source power where we have energy. Akere?”

Learners: “Yes.”

Teacher: “So these bulbs are going to switch off just like that because our potential difference is busy decreasing. It is very important. That point is the one that is very important. Then comes another problem. We'll make a conclusion again to say, ok, let’s talk about current. Why am I talking about potential difference and current? It is because, I’m relating the 2 according to Ohm's Law. As we move, we are going to use Ohm's Law to calculate everything in our circuit. Akere?”

Learners: “Yes.”

Teacher: “Now, let’s check our total current. The current that will be passing in this kind of connection, the current that is going to pass there (Writes on board $I_t=I^1=I^2=I^3$) is the same throughout. Ke a hotlwahala neh?”

Learners: “Yes.”

Teacher: “The current that is going to pass through this kind of connection, is the same throughout. And please, back that in your mind, current it is an independent variable. Charges will always pass. It doesn’t matter where there resistor is. But the charges will always prefer the easy path. We can go to the next connection if we don’t have questions. Any questions? Hulumani kele lahlile. Any question? No question? Are you sure? No comment? No question? No comment? No nothing? Let’s go to connection number 2 which are parallel. Aowa. According to Mathematics, as you are aware you know about parallel lines right?”

Learners: “Mhmm.”

Teacher: “Ya. So the parallel connection would be this one (draws on board). This is the tricky part of electric circuit, neh? If you understand this tricky part, ah then….. Ah, no. Let me start with 2 (corrects drawing on board). Let me start with 2 then we go to 3 and 4 and so on. Eish! Now whatever I was said there, is vice-verse. The conclusion that was said on Series Connection is vice-verse. If you understand vice-verse. Anyone who can explain or say something about vice-verse of that? And put it there (pointing to the drawing on board). Yebo!"

Learner: "Ok. When you say it's vice-versa, you mean that the potential difference, neh, at the series connection was different throughout the resistor. Throughout the circuit. Now because it's vice-versa, the potential difference is the same throughout."

Teacher: "Awu. Are Vt will be the same as V that is at 1 and V that is at 2. ($Vt=V^1=V^2$) And then what about the current part? Anyone? Anyone about the current part? The current part. Lesatshaba go bolela. Why be afraid of talking? We have freedom of speech musi. We have freedom of speech and answering. You can give me the answer that is in your head so that I can correct you now.Huh? Ok, this one is the part that I like more than the other part. Ok, because we have said that this is vice-versa. Now the current that will be passing through (writes on board), through a parallel connection will be divided according to the proportion of the resistors. Oh, when it is divided we do this (draws on board). We'll be doing what? Will be divided. Let me wipe this side (the portion of board where he first wrote on). I'm going to explain this critical point, and when I'm done explaining this critical point, any question that can come, whether it's a Grade 12 question paper or what, ah you you will be fine from now on. Whether final paper you don't know the question, you can tell yourself to say I'm going to get a 2 out of those one. Out of electric circuit questions. Now I'm going to redraw the very same diagram. I think this side is better, let me make something here. (Draws on board) Ehrr… let me make point A and point B there. And write R^1 again and write R^2 there. Because I've said that the total current that is passing through a connection is divided according to the proportion of resistors. Now we are going to explain it further so that you understand it very well for future references. Now at point A the current will be coming in this direction, huh?”

Learners: “Yes.”

Teacher: “When we are saying this direction we must look at a positive terminal gore itla from which side. Are we clear?”

Learners: “Yes.”

Teacher: “Positive terminal from your circuit. Now we’ll assume that or positive terminal is on this side coming this way. Ok, now at point A, because from here until point A, we are having a Series Connection. That means the current is the same until point A. Because from here until point A, it is still a Series Connection. Now when we pass through point A, the current is divided. The current is going to split. The other current is going to go in that direction, the other current is going to come down. Are we clear?”

Learners: “Yes.”

Teacher: “Now after passing through the resistors, at point B, their current goes back to be the same as point A. That means the current at point A and the current at point B is the same. Are we clear neh?”

Learners: “Yes.”

Teacher: “Now, because I told you that when we want to go out from that door, as people because these people are now charges, they will prefer to take the easy path. Ok?”

Learners: “Yes.”

Teacher: “Ok, now if we are having identical resistors, the current that is going to go to Resistor 1 and Resistor 2 is going to be the same. Why? Because the resistors are identical. That is point number 1. Now, if the resistors are not identical, let's just assume we have 2 ohm here (labelling on the board) and then we have 5 ohm. I don't want the numbers that goes in terms of ratio of 2:4. The one that goes in terms of ratio 2:4 it's easy. I prefer 2:3, 2:5 and 7. Now another very important point, you must write it underneath parallel connection is this one, a s we agreed and made a conclusion to say, if a parallel connection, a parallel is divided according to the proportion of the resistors. Therefore, the biggest current will pass through the smaller resistor. And the smaller current will pass through a smaller resistor. I'm repeating myself, because we agreed that this current is going to be divided according to the proportion of the resistors, therefore the bigger current will pass through the smaller resistor. Akere? Bigger current pass through a smaller resistor, and then……"

Learners: "Small current pass through a bigger resistor."

Teacher: "Ok, I talked about the resistors. I said the door will resist us from moving out. The door A, because ke monyako mmonyane, era gore the resistor yagona igolo neh? Does it allow many people to pass? It allows few people to pass. Because these people are the ones that are called charges and the rate at which these charges pass through is current. The smaller the door the bigger the resistance and it doesn't allow many people to pass. The bigger the door the smaller the resistance. It allows many people to pass. It's the same thing that is there. Now I want to show you how to calculate those things. Because I have talked about the word proportion from grade 10, you did what is called weak point theorem. They taught you about proportionality. The first thing that you need to do is to add the resistors. Step number 1 is to do what?"

Learners: "Add the resistors."

Teacher: "Today, we are having 2 ohm and 5 ohm. When we add them together we have a total of…."

Learners: "7 ohm."

Teacher: "Let me make this very clear because it can be a contradiction, it is NOT the total resistance, neh?"

Learners: "Yes."

Teacher: “You don't calculate for total resistance but it just adding these two. When you want to calculate the total resistance for a parallel connection, it’s 1/R equivalent or R external which is equal to $1/R^1$ + $1/R^2$ please. Akere? We are not looking for such, we are talking about proportionality. We want to explain the part of current. Akere?”

Learners: “Yes.”

Teacher: “Ok. Now we first add them together, we get the total of….”

Learners: “7 ohms.”

Teacher: “When we want to identify the current that is passing here, what is it that we are going to do? We are going to use the biggest resistor to determine the current that is passing at the smallest resistor. And when we want to determine the current that is passing here we use a different resistor. Kea hotlwahala neh?

Learners: “Yes.”

Teacher: “Now, if we want to determine the current that is passing here (pointing at the board), we will say that the current at 5 ohm resistor, it is equals to 2 over 7. Ke krea kae this 7, I have added these 2 together. It is 2 all over 7 multiplied by the current that you have on a Series Connection. You just determined the current that is passing there (Ponting at equation on board). Neh?

Learners: “Yes.”

Teacher: “When you want for I^2 you say 5 all over 7 multiplied by the current at the Series Connection. When we add these 2 together, we must get the total current at the Series Connection. I hope you are clear. Why are we doing this? The purpose of doing this is to make sure that it results at going back to a potential difference that is the same. Akere keaotlwana?”

Learners: “Yes.”

Teacher: “Yes because if we don't do that, the potential difference that will be passing here, won't be the same as the potential difference that is passing there. If you add your current together, and your current does not give you that of Iţ, which is on Series, your potential difference will be wrong. The other one will be 7 the other one will be 2. You must have 7. Let meet come illustrate that with example because the only way to learn is by example. That's Einstein, the quotation from Einstein. I just like things from my head. I prefer myself more than the book. Because the book ikwetsi ke motho. And then if ikwetsi ke motho aka dira phoso wabona? But my knowledge is better, it's there wabona? Because it's very rare to do a mistake from what I know. Now, we have a 3 ohm there. Now if I can put any resistor there of 7, the current that is going to pass there, is 3. Are we clear?

Learners: "Yes."

Teacher: "The current that is passing there is what?"

Learners: "3"

Teacher: "And not it will be easy to determine the potential difference that is passing there. Akere? Because you have 2 things according to Ohm's Law which is R=V/I and when I play with this I know that V=IR. Now because I know 2 things then I can calculate for potential difference. But, no, we are not there. We are here (pointing at the writing on the board), we want to get this point very clear. Because once we understand this point, aowa, electric circuit. I can put any previous question paper here now you will be done with it. Ah ok, oh yeah, it's 3 akere? Now when it reaches this point it was split, and as it splits we agreed that it will split according to the proportion of the resistor. Now the first point is to add them together. You get what?"

Learners: "7."

Teacher: "Now, we must know the current that is passing here. In order for you to know the current that is passing there, you must say, a current at 4 ohm resistor, it is equal to 3/7 multiplied by 3. Why this 3? It is our….."

Learners: "Current."

Teacher: “The current there is where? In our Series Connection. Akere? Now you play with your calculator, you get 9/7 which is 1 point something. 1 point 5 something. Press there, check there. If you want me to do it, it's fine. 9 all over 7 goes once, you are left with 2. Ehrrr goes twice, you are left with 6. It goes 5 times….I think let's just leave it there. 1,3 let’s love there and round it to 1,3. Ke right musi or ake right? Ke 6 mo?

Learner: “8.”

Teacher: “Ke 8 neh? Ya, you are correct. 1,3. Let’s take 1,3 neh? And we have 1,3 Amperes. Let's calculate for the current that is passing where? There! (Pointing at the 3 ohm resistor). Current that is passing at 3 ohm resistor is equal to 4 all over 7. Why am I taking 4? Because we are in the current of the 3 ohm resistor. Multiply by 3, akere?”

Learners: “Yes.”

Teacher: “Ah you already know the answer. The answer must be 1,7. But let’s do that. But it’s fine. 3 times 4 is 12, all over 7. 12 goes how many times? 1. And gosala bokae mo? Gosala 5 akere? Put a comma. 7 goes how many times there? 7 times. Because you must put a 0 and it will be 7 times. You are left with 1. 7 goes how many times into 10?”

Learners: “1”

Teacher: “So ah it won’t change. It will be 1 point 7. So the answer to this is 1 point 7 Amperes. And if I add the 2 because it must add there at B, it must give me….”

Learners: “3.”

Teacher: “You see musi neh? Now this current is divided according to the proportion of the resistors. You can verify that by calculating for the potential difference that is passing here and the one that is passing there. It must be the same. V equals to I I. It's going to conclude this point. Akere laotlwana?”

Learners: “Yes.”

Teacher: "Let's calculate that and see. Here we are having 3 as our R. 3 multiplied by 1,3?"

Learner: "3,9"

Teacher: "4 multiplied by 1,7? Ayi ayi ayi. I did a big mistake, 1,4 must multiply 3, sorry. Akere now the current that we have is for 4, hee?"

Learners: "Yes."

Teacher: "Ya. 1,3 must multiply 4. 5,2. Ok. Here it's 5,2 neh? 1,7 multiplied by 3 is 5,2. Ke yona neh?"

Learners: (murmuring)

Teacher: "1,3 multiplied by 4 equals 5,2. Kante lereng? 1,7 multiplied by 3 ke 5,2 ashe le kwetsi akere? 1,3 multiplied by 4 ke 5,2 hape. Oh ke erile vice versa, 1,7 multiplied by 3 it is 5,2. 1,3 multiplied by 4 it will be 5,2. Verify that with a calculator. Ke yona neh? Ya. Akere?"

Learners: "Ke yona."

Teacher: "Yes. Because, Ke yona?"

Learners: "Ke yona."

Teacher: "Ke yona, akere layibona akere? So it concludes this statement to say, the potential difference that is passing through a parallel connection is the same. If I give you the potential difference there, you must already know that you have got the potential difference for the other resistor. Akere? Ya. Even if it's another resistor that is somewhere as long as the connection is parallel. Akere?"

Learners: "Yes."

Teacher: "But the current is different. Are we clear with that?"

Learners: "Yes."

Teacher: "Ok. Let's do this question. I can tim here neh?"

Learners: "Yes." (Bursting into laughter)

Teacher: "(while erasing the entire board) it's one and the same thing. You know why it's one and the same thing? Because at the end you don't have nothing. The result is the same. Switching off and erasing, ah, the answer will be blank. So, why worry now? Why worry about the English because you are Mathematicians and Scientists. Why worry about the English? As long as we both heard what I'm saying. According to this November of paper, I'm going to draw a structure there and after drawing a structure there, I'm going to answer…..yoh what's wrong? (Analyzes question paper in his hands). Oh, you have it?"

Learners: "Yes."

Teacher: "Oh, let's do November 2015. Oh you don't have it, it's fine. Let meme just draw the diagram because we need to explain while looking at it. Ah number 1 it's simple. But it's fine. Little things. Nna I can tell you. Those who don't have it, I know gore baetsing. Nkale botsa. Kaetsi. Since something is being decriminalized, barekesetse mmerokong. But akenyaki go bolela gore keng mmereko wa teng. The circuit below is used to determine the resistance or the resistors there. November 2015 neh? It says that while volts battery has internal resistance. Retlo era internal resistance next year. Now, all there is, is a case that it is negligible, it's very small. When switch S is closed, the reading on the ammeter is 0,5 Amperes. Number 1 is saying state Ohm's Law in words. We just did that ok. We must know that. Always the case, as I have said, there are 99% chances tomorrow. You will see that. 11.1.2 Calculate the resistance of resistor X. Are boleleng gore retla ira jwang? Nna kaitsi. Go e bala fela kiyitlile. Because I know the Ohm's Law. Ohm's Law is going to work. Because it's the only thing I'm going to use. Then with other formulas, yes, of power and so on and so on but, ya. Ah that one is straight forward. Areboleleng."

Learner: "We first find the current in Amperes passing through resistor A."

Teacher: "Resistor A?"

Learner: "Yes"

Teacher: “Which is how much?”

Learner: “Which is 1,5.”

Teacher: “1,5 why?”

Learner: “Because 12 divided by 8 equals to 1,5.”

Teacher: “Go back to my notes and check a Series Connection. Please let’s go back to my notes and check Series Connection. And tell me there, whatever that I’ve said is very critical, very important to know. On Series Connection, it’s a point. I have said something there. I’ve said what? Tell me please.”

Learners: “The current is the same.”

Teacher: “You are given current, isn't that so? Which is 0 comma?

Learners: “5”

Teacher: “That means the current that is passing there is how much?”

Learners: “0,5”

Teacher: “And the one that is passing there is?”

Learners: “0,5”

Teacher: “Yes. Lae bona akere? That means we know the current that is passing here and the current that is passing…”

Learners: “There.”

Teacher: “Ke point number 1. Isn’t it so? Then what is it that we can do? I go back to you. We know one thing, we know this. That means it's either we have to find this or that. Mara V aba refa.”

Learners: “Barefile”

Teacher: “Ke bo kae?”

Learners: “12”

Teacher: “Ah why now stress because you have everything? Why stress? Ke sa Oupa neh?”

Learners: (Laughter)

Teacher: "Then we can calculate what here?"

Learners: "Resistance."

Teacher: "And the resistance that I'm calculating is which resistance if I may ask?"

Learners: "X"

Teacher: " Is Resistor what?"

Learners: "X"

Teacher: "For 5 marks? I doubt. For 5 marks? There's no way you can write 2 things and get 5 marks. Irs a story. Every time you get a 5 mark question on this, it means you must do something. Then take that thing to use to determine whatever the question is asking. Every time a 5 mark question on electric circuit, it says I must do something first. Then I'll take whatever that I've done and use it to determine the final answer. Straight forward question, 3 marks. 1 mark for substitution, 1 mark for the answer and 1 mark for the unit. If you remove the unit, I'll give you that mahala. Akere laotlwana neh? 3 marks are straight forward questions. So because it's 5, I need to do something 1st. That means that the resistor that I'm determining is which resistor? It is the total resistor of the circuit. So now we are getting that as 12 over what?"

Learners: "0,5"

Teacher: "That is 24. Ke yona?"

Learners: "Yes"

Teacher: "Ka nnete?"

Learner: "Don't" (laughter)

Teacher: "Now this 24 is which 24? It's the total resistance of these 2 resistors. Akere. Now because you have connected these 2 resistors in series, what is it that you need to do? The external resistance equals to Resistor 1 plus Resistor 2. But Resistor 2 is X neh?"

Learners: "Yes."

Teacher: "Resistor 1 is said and the total is 24 Ohm is equal to 8 Ohm plus X. Then X will be…."

Learner: "16"

Teacher: "16 Ohm. That means Resistor X is 16 Ohm. Any questions? Any question? Any comment? Those ones were just easy stuff neh? We will get to the main things. That one I'm not going to answer it. I'm going to explain it, people must do the answering because I'm not the one who's going to write. I know them all, you can bring any question. I'll just give you the answer before I calculate. Why? Because they are in my system you know. There's a book somewhere hey. I have a book that they used to do these question papers somewhere."

Learner: "Give us Sir." (class laughs)

Teacher: "I'm busy doing that. I'm busy doing that. Isn't it so? Yes. I'm busy doing that. As long as you understand those critical points of parallel connection and everything, then we are fine. Free to go. Another parallel connection again. Eish, I like this question because I am a Raul. I know what to do with it. Study the circuit below. The battery has 12 volts with negligible internal resistance. Now switch S is closed. When switch S is closed, write down the potential difference across the 4 Ohm resistor after you Switch S closed. Now I'm going to explain what's going to happen there. Then after, you write. But 11.2.3 because I did not give you, but you know because it's revision. They are looking for the energy that is distributed in the 12 Ohm resistor. Please don't forget that we have power, and power is the rate at which work is done. But work is still having a definition because work has something to do with energy. So that means power can be something to do with energy over time. So don't forget about that. So I'm going to explain this diagram of mine. Now after I switch or I close the switch, what's going to happen? The current will come (illustrates on the board) when it reaches this point, the current is going to be divided according to the proportion of the resistors. These resistors and these resistors. But now these resistors added together, because now they are also connected in parallel connection. I must take these 2 resistors and add them together. And take these 2 resistors and convert them to a Series. That's the first point I really need to do. Are we clear? So that I can determine the current that will be passing there and the current that will be passing here. But now the same current that is passing here is going to split again here. Kea otlwahala?"

Learners: "Yes"

Teacher: "And is going to be divided according to this proportion again. And add back. But when it is here, it's the same as the current that is there. Even there, it's the same as the current that is passing there. Akere la otlwana? Because the current that is passing here is the same as the current that is passing there. Why?"

Learners: "Because it's a Series Connection."

Teacher: "But now from here, the current splits. Akere kea otlwana?"

Learners: "Yes."

Teacher: "The current splits. Then we can be able to answer the question. Please let's answer the question so that we can do the correction. I give you 10 minutes because it's 5, 5. November, 11.2

APPENDIX N:

OBSERVATION PROTOCOL CASE 3

Teacher: “Ok. Ohm's Law States that the amount of electric current through a metal conductor at a constant temperature in a circuit is proportional to the voltage across the conductor. Are you here? So according to the definition here, erebontsa gore, R = V/I, where R is the resistance and the resistance is measuring what?”

Learners: “Ohms.”

Teacher: “Akere? Then V is for our potential difference, akere? And then is measured in what?”

Learners: “Volts.”

Teacher: “Volts akere? And then current? SI unit for current?”

Learners: “Amperes.”

Teacher: “Amperes, akere? So there are 2 types of circuits. We have a Parallel Connection and then a Series Connection. Under Parallel, go eragallang in terms of potential difference and current? From Grade 10 under parallel.”

Learner: “Under parallel, voltage is the same.”

Teacher: “Voltage is the same.”

Learner: “Throughout the circuit.”

Teacher: “Throughout the circuit. And then? What about current?”

Learner: “Current is divided.”

Teacher: “Current is divided, akere? Ok under parallel connection, the potential difference is the same. And current is divided kedi current dividers and then potential difference is the same. Meaning, $V_t=V^1=V^2=V^3$ depending on circuit yarona itlabe ile potential difference ebokae. Akere? Then current he bare current dividers bare $I_t=I^1+I^2+I^3$ akere?

Ko depender gore gonale amp meter tse kae mo circuit ya rona akere? Then resistance is Rţ=R^1+R^2+R^3 akere? Ke parallel akere?”

Learners: “Series.”

Teacher: “Oh Series. Let’s go to parallel. 1 over, 1 over, 1 over (writing on board). Ok, rea koSeries akere? Series, current is the same. Meaning I total (Iţ) is equals to I one (I^1) is equals to I two (I^2) is equals to I three (I^3). Akere? Then V potential minus. Meaning V total (Vţ) is equals to V one (V^1) plus V two (V^2) plus V three (V^3). Akere? Therefore total resistance ya teng R total (Rţ) is equals to R one (R^1) plus R two (R^2) plus R three (R^3). La e bona?”

Learners: “Yes.”

Teacher: “So let's take the relationship between potential difference and resistance. What is the relationship between potential difference and resistance? The difference between potential difference or voltage and resistance. Mojapelo.”

Learner: “Voltage and resistance are directly proportional.”

Teacher: “Voltage and resistance are directly proportional, akere? And the relationship between current and resistance? Maphangu.”

Learner: “Current and resistance are inversely proportional.”

Teacher: “Current and resistance are inversely proportional, akere? And then le bona from Ohm's Law. So, kelefile question paper yaNovember 2015. Let's go to question number 11. The circle below is used to determine the resistance of resistor X. La e bona?”

Learners: “Yes Sir.”

Teacher: “Part of Bolt's battery has internal resistance when switch S is closed, the reading on the Amp meter is 0,5 Amperes. State Ohm's Law in words. Question 11.1.1. Then Question 11.1.2 Calculate the resistance of resistor X. Akere? Ok ke mang aka le state lang Ohm’s Law in words? Question number 1. Miss.”

Learner: “The amount of electric current through a metal conductor with a constant resistor X is proportional to the voltage across the conductor.”

Teacher: “Ok, the amount of electric current through a metal conductor at a constant temperature in a circuit is proportional to the voltage across the conductor. Akere? Meaning R=V/I. Ok, are eating question number 2. Calculate the resistance of resistor X, 5 marks. Nkeletseng yona 3 minutes.”

Learners: (working on the question)

Teacher: “Ok, le feditse? The circle below is used to determine the resistance of resistor X. The 12V battery has an inclusive internal resistance. When switch S is closed, the reading on the Amp meter is 0,5 Amperes, akere? Ke mang aka re yeletsa yona?”

(Learner rises to write on board answering the question)

Teacher: “Ok. O eletsa tsona? Ye?”

Learners: “Yes Sir.”

Teacher: “Who got a different value? (in SeTswana) E ko file bokae?”

Learner: (walks towards chalkboard to write his answer)

Teacher: “Ok, ari R=0 because the switch is open so there is no current passing through. And omongwe o kreyile 16. Anyone with a different answer from these 2? (in SeTswana) Ok, when switch is open, ha hona current that passes through. You are correct. When switch is open, there's no current that passes through. Akere? A hona the flow of current. But heso, ari the 12V battery has internal resistance. When switch S is closed, the reading on the Amp meter is 0,5, akere? From the diagram the switch S is open but the reading says when switch S is closed the reading on the Amp meter is 0,5 Amperes. So there's a flew of current. While or resistance is not 0. And then ha re tshekile circuit eyo, the resistors are connected in series, akere? And the under series laitsi gore current is the same. O rang both resistor in ohms and X o shera the same amount ya eng, ya current. And then the total potential difference which is 12V. Then ra user Ohm's Law to calculate the unknown resistance, which is resistance X. Number 1, determine the total resistance using total potential difference and total current. Then you found the total resistance, akere? Since our circuit is connected in series, we Rţ=R^1+R^2. We know or Rţ which is 24 and then R^1 is 8 Ohms. So our R^2 is equal to 16 Ohms. La e bona?”

Learners: “Yes.”

Teacher: “Ok, let’s go to 11.2. Study the circuit below. The battery gives us an EMF of 12V with variable internal resistance. But switch S is closed. Wa e bona? So always, lebella the diagram. Hao fetsa go lebella the diagram then check the statement. From the statement bare switch S is closed. Wire down the potential difference across the 4 Ohm resistor. Ok before reya ko questioning, are checkeng the diagram. We have 2 resistors that are connected in series. And the other 2 that are connected in parallel. Akere?”

Learners: “Yes.”

Teacher: “Ari write down the potential difference across the 4 Ohm resistor. The 4 Ohm resistor is connected in parallel with the 16 Ohm resistor. Akere? Then laitsi gore after parallel connection, potential difference is the same. And then current is divided, la e bona?

Learners: “Yes.”

Teacher: “And then, what is the reading across the 4 Ohm resistor?”

Learner: “12 volts.”

Teacher: “Why 12V?”

Learner: “4 Ohm resistor is connected in parallel.”

Teacher: “Mokhari ari 12V because 4 Ohm resistor is connected in parallel. Since in parallel connection, potential difference is the same. O mongwe areng? Ok it’s 12V, why because the 4 Ohm resistor is connected in parallel. Then 11.2.2 Calculate the reading on the ameter. 5 minutes. Number 1, calculate the total resistance, akere?”

(Learners working out individually while teacher walks around checking)

Teacher: “Lefeditse mmusi? One minute. Ok. Study the circuit below. The battery has EMF of 12V with variable internal resistance. Switch S is closed. Akere? So calculate the current on the Amp meter. Akere? So i

Learners: “0.5”

Teacher: “Ok. Ohm's Law States that the amount of electric current through a metal conductor at a constant temperature in a circuit is proportional to the voltage across the conductor. Are you here? So according to the definition here, erebontsa gore, R = V/I, where R is the resistance and the resistance is measuring what?”

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Teacher: “Volts akere? And then current? SI unit for current?”

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(Learner rises to write on board answering the question)

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Teacher: “Ok, ari R=0 because the switch is open so there is no current passing through. And omongwe o kreyile 16. Anyone with a different answer from these 2? (in SeTswana) Ok, when switch is open, ha hona current that passes through. You are correct. When switch is open, there's no current that passes through. Akere? A hona the flow of current. But heso, ari the 12V battery has internal resistance. When switch S is closed, the reading on the Amp meter is 0,5, akere? From the diagram the switch S is open but the reading says when switch S is closed the reading on the Amp meter is 0,5 Amperes. So there's a flew of current. While or resistance is not 0. And then ha re tshekile circuit eyo, the resistors are connected in series, akere? And the under series laitsi gore current is the same. O rang both resistor in ohms and X o shera the same amount ya eng, ya current. And then the total potential difference which is 12V. Then ra user Ohm's Law to calculate the unknown resistance, which is resistance X. Number 1, determine the total resistance using total potential difference and total current. Then you found the total resistance, akere? Since our circuit is connected in series, we Rţ=R^1+R^2. We know or Rţ which is 24 and then R^1 is 8 Ohms. So our R^2 is equal to 16 Ohms. La e bona?”

Learners: “Yes.”

Teacher: “Ok, let’s go to 11.2. Study the circuit below. The battery gives us an EMF of 12V with variable internal resistance. But switch S is closed. Wa e bona? So always, lebella the diagram. Hao fetsa go lebella the diagram then check the statement. From the statement bare switch S is closed. Wire down the potential difference across the 4 Ohm resistor. Ok before reya ko questioning, are checkeng the diagram. We have 2 resistors that are connected in series. And the other 2 that are connected in parallel. Akere?”

Learners: “Yes.”

Teacher: “Ari write down the potential difference across the 4 Ohm resistor. The 4 Ohm resistor is connected in parallel with the 16 Ohm resistor. Akere? Then laitsi gore after parallel connection, potential difference is the same. And then current is divided, la e bona?

Learners: “Yes.”

Teacher: “And then, what is the reading across the 4 Ohm resistor?”

Learner: “12 volts.”

Teacher: “Why 12V?”

Learner: “4 Ohm resistor is connected in parallel.”

Teacher: “Mokhari ari 12V because 4 Ohm resistor is connected in parallel. Since in parallel connection, potential difference is the same. O mongwe areng? Ok it’s 12V, why because the 4 Ohm resistor is connected in parallel. Then 11.2.2 Calculate the reading on the ameter. 5 minutes. Number 1, calculate the total resistance, akere?”

(Learners working out individually while teacher walks around checking)

Teacher: “Lefeditse mmosi? One minute. Ok. Study the circuit below. The battery has EMF of 12V with variable internal resistance. Switch S is closed. Akere? So calculate the current on the Amp meter. Akere? So i

Learners: “0.5”

Cont….

(Learners writing on chalkboard)

Teacher: “Ok, another one with a different answer? Ok, ari starteng ko white board. O calculatile the total resistance of parallel connection between 16 and 4 , akere? Akere, the flow of current it flows from positive to negative terminal. And then there is branch that divides from 12 Ohm resistor and 16. La e bona?”

Learners: “Yes.”

Teacher: “12 and 16, they are connected in parallel. And then 16 and 4 they are also connected in parallel. And 12 and 8, they are connected in series. If u-checka our position of our ammeter, mo bae connectile ko teng akere, la o tlwana?”

Learners: “Yes.”

Teacher: “…………………………… Number 1, u-calculate the total resistance ya-parallel. Keng R parallel is equals to product divided by sum, akere? (Writing on board)Number 1, Rparallel = product/sum or

$1/R_{parallel} = 1/R^1 + 1/R^2$. Akere? Remember reberekisa this formula if there's 2 resistors connected in parallel. Ne reli more than 2, retla berekisa ela. So it's the same as $(R^1 \times R^2) / (R^1 + R^2)$. Is (16 x 4) / (16 + 4). 64/20 therefore our R parallel 3,2 Ohms, akere? Remember the question babatla eng, bare calculate the reading on the ammeter. Re nale a total resistance e fetang ko kae? Write the total resistance ya parallel connection ya rena. Akere? So if current efetang ko16 and yako 4…………………. R=V/I neh? Potential difference divided by current. (Does calculations on board). Our total resistance is equal to 3,2 Ohms is equal to the total potential difference, 12, divided by I. (Does calculations on board) So our current is equals to 3,75… La otlwana?

Learners: "Yes"

Teacher: "Or reka calculater current e passang through the 16 Ohm resistor, then rekafetsa re calculater the current e-passang through the 4 Ohm resistor. Then after that, ra e adder then rofa the total current. Akere? A re checkeng. (works on board). Ok, for 16R ke yona V=IR, akere? Our total potential difference is 12. Therefore 12=I(16), I=12/16 which is equal to 0,75. (Same method of calculation for the 4 Ohm resistor and answer is 3). Therefore, I = 3+0,75 = 3,75A. La e bona?"

Learners: "Yes Sir."

Teacher: "Ok, Question 11.2.3 Calculate the energy displayed in the 12 Ohm resistor in 2 minutes. Akere? Remember we have to convert minutes to seconds. One minute is equivalent to 60 seconds. Therefore, 2 minutes is equivalent to 120 seconds. Ok let's calculate Question 11.2.3. Ehrr… 4 minutes.

(Learners work out answers individually)

Teacher: "Number 1, P = VI. Then number 2, $P = I^2R$. Then number 3, $P = V^2/R$. Then number 4, P = W/T. Then the last one, W = PI. So for question ela reberekisa which formula? R = 12 Ohms. T = 120 seconds. Then babatla eng, calculate the energy. 5 marks. Number 1, we don't know the current e-passang through the 12 Ohm resistor, akere? Re rata re calculate current e-passang through the 12 Ohm resistor. Then the potential difference e-passang through the 12 Ohm resistor. So, calculate the potential difference e-passang through the 12 Ohm resistor, or current ya di 12 Ohm resistor. Not the potential difference e-passang through the 12 Ohm resistor. Current e-passang through the 12 Ohm resistor. La o tlwana? Calculate current eyo. I wouldn't know the current e-passang ko16 and 4 Ohm but we don't know the current e-passang through the 12 Ohm resistor. Cause, Ehrr, 16 and 4, they are connected in parallel with 12 Ohm resistor. They are usually the same current. But current e-passang through the 12 Ohm resistor keyona e-passang through the 8 Ohm resistor. 0,6A. You write our current is equals to 0,6A. O arrivile beyang to 0,6A?"

Learner: "The total resistance in the circuit Rţ.= (Learner rises to write on board).

(Learner explains his calculations to the class)

APPENDIX O:

TURNITIN REPORT

EXPLORING THE NATURE OF TEACHERS CLASSROOM PRACTICES WHEN TEACHING ELECTRIC CIRCUITS IN A GRADE 12 CLASSROOM ; A CASE IN THE TSWANE WEST

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APPENDIX P
EDITORS CERTIFICATE

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"Perfection is our DNA"

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12 December 2018

To whom it may concern

This letter is to confirm that I, Keegan Bruce Schmidt, freelance copy-editor, have edited and proofread the proposal ***"exploring the nature of teacher's classroom practices when teaching electric circuits in a grade 12 classroom: a case in the Tshwane west district" by Vonani Japhta Ramashia*** grammar and spelling.

I have not changed any of the ideas presented in this proposal, only the grammar and spelling has been altered for the purposes of clarity. This is to confirm that I have edited the document to a level I deem satisfactory.

Should you have any questions feel free to contact us

Keegan Schmidt
Qualifications:

- BIS (University of Pretoria)
- BIS Hons (University of Pretoria)